THE RESOURCES AGENCY OF CALIFORNIA

Department of Water Resources

BULLETIN No. 111

SACRAMENTO RIVER WATER POLLUTION SURVEY

APPENDIX C

PUBLIC HEALTH ASPECTS

By
Department of Public Health, Division of Environmental Sanitation
Department of Public Health, Division of Laboratories

AUGUST 1962

EDMUND G. BROWN
Governor
State of California

WILLIAM E. WARNE
Administrator
The Resources Agency of California
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CHAPTER I. INTRODUCTION

The Sacramento River has performed many valuable services through the years for the people of California. In addition to its role as an artery of commerce, the waters have found increasing use as a source of domestic and industrial water supply, a site of recreational activities, and a spawning area for a large portion of the State's game fish. These uses have increased in proportion to the rapid agricultural, industrial, and residential development of the Sacramento Valley. With the development of The California Water Plan the river will play an important part in supplying water to water-deficient areas in the south. The river has also served as a vehicle for the disposal of sewage and industrial wastes from some of the communities along its banks and agricultural drainage from irrigated areas.

Present waste discharges to the Sacramento River can be said to be "few and far between" when compared to the waste discharges entering other rivers in heavily industrialized areas of the country. In these areas, however, the people have suffered the loss of many of the beneficial uses of the river and experience has pointed out the difficulty in attempting to regain beneficial uses that are once lost. The Sacramento River Water Pollution Survey is an important step toward the preservation of the beneficial uses of the Sacramento River.

After an initial planning period, the field work for the Sacramento River Water Pollution Survey was undertaken by the State Department of Water Resources in March 1960, and continued until June 30, 1961. The scope and direction of the survey work was overseen by an advisory committee made up of members of the Department of Water Resources, Central Valley Regional Water Pollution Control Board, Department of Fish

and Game, and Department of Public Health. The work was classified under six major headings: Hydrology, Water Utilization, Laboratory and Field Procedures, Water Quality, Public Health, and Fish and Aquatic Life.

When water is used for domestic, certain recreational and agricultural purposes, public health considerations are paramount. Where the public health aspects of water quality were the most important, the study was directed by the California State Department of Public Health. This appendix contains that portion of the survey related to the public health.

Authorization of Study

As a result of a series of meetings held among a number of State agencies, the need for a pollution survey of the Sacramento River was established in 1957. In subsequent meetings between the Department of Water Resources and the Department of Public Health, it was recognized that the Department of Public Health could make a valuable contribution in the planning and conduct of the survey. It was agreed that by virtue of specialized experience, the Department of Public Health was most competent to perform certain types of analyses of the river water and could contribute significantly to the survey by overseeing the collection and evaluation of data pertaining to the public health aspects of the study.

Assembly Bill 2904 in 1959 appropriated funds from the California Water Fund for expenditure by the Department of Water Resources to study and investigate pollution in the Sacramento River.

In April 1960, the Department of Public Health and the Department of Water Resources entered into an Interagency Agreement whereby the Department of Public Health would provide laboratory services and the services of a sanitary engineer to evaluate and report on the public health aspects of the study.

Objective and Scope

The major objective of this phase of the survey was to study and evaluate the quality conditions in the Sacramento River and their relation to the public health. This objective was reached in two steps.

The first step was to locate present waste discharges and to evaluate their effect on the river. These discharges were surveyed and an attempt was made to establish, by sampling and analysis, the amounts of specific contaminants discharged to the river. The effects on the river water quality were determined by a number of comprehensive river sampling programs taking into consideration various waste loadings and flows including the worst expected conditions.

The second step was the determination of the type, location, and extent of the uses of the Sacramento River that are particularly related to the public health. To accomplish this, surveys of the domestic water systems along the river and field investigations of the recreational uses of the river were made.

These findings were combined to achieve the major objective of the study, namely, the public health evaluation of water quality conditions.

The survey was directed at and limited to the main stem of the Sacramento River from Shasta Dam to Mayberry Slough which is near the confluence of the Sacramento and San Joaquin Rivers. The field investigation, sample collection, laboratory work, and evaluation were designed to determine the causes, effects, and degrees of change of the water quality in the main channel of the river. Sampling of the many accretions was generally limited to the point at which they entered the river. Little field work was done upstream on the tributaries and drains.

Area of Investigation

The Sacramento River flows for a distance of 310 river miles from Shasta Dam to Mayberry Slough (Plate 1). The river can be divided into three sections in terms of the uses made of its adjacent lands. In the upper reaches, the river bed is wide and shallow with many riffle areas. The valley in this area is narrow, heavily wooded and contains several small communities as well as the towns of Redding and Red Bluff. The economy of this area is based predominantly on farming, logging and wood processing.

In the middle reach, the valley broadens and the bottom land is used for agriculture. The land is ideally suited to rice production and rice is the major product of the area. The river banks in this reach are higher and the velocity decreases as the river deepens. Small agricultural communities, a few of which are close to the river, are located throughout this portion of the valley.

The Sacramento River in the lower reach flows through the section of the valley which has been mostly highly developed for residential and industrial purposes. High levees have been constructed to protect the rich agricultural lands and communities. The City of Sacramento is the major commercial center in the lower reach as well as in the entire valley. Fruits and vegetables grown in the valley are processed at canneries in the city. Beef and other meat products are prepared for market at slaughter houses located in the West Sacramento area. Granaries, rice mills, dairies, and other industries in Sacramento handle the products and needs of the valley.

The Feather and American Rivers which drain watersheds to the east, are the two major tributaries to the Sacramento River below Shasta Dam. They join the Sacramento River 20 miles above Sacramento and at

Sacramento, respectively. There are numerous minor tributaries along the northern reach of the river which drain small watersheds and are normally dry or have extremely low flows during the summer months.

In the upper reach, there are two significant discharges from sewage treatment plants and several minor discharges from log ponds and paper mills. In the middle reach of the river, the only discharges are from the network of drains carrying agricultural drainage to the river. In the more populated and developed lower reach, there are numerous effluents from sewage treatment plants entering the river either directly or by means of tributary drains and rivers, and a large seasonal flow of industrial waste from a sugar beet processing plant below Sacramento.

Related Investigations and Reports

The State Department of Public Health has made many investigations related to the Sacramento River throughout the years. Studies have been conducted to determine the effect of waste discharges on water quality. Periodic inspections and surveys of domestic water systems using Sacramento River water are made by the State and local health departments. Investigations of recreational activities along the river have been made to determine the types and extent of this use of the waters. Sewage treatment facilities have been inspected routinely and recommendations of improved treatment procedures have been offered to the waste discharger. The department's investigations have been usually confined to specific areas for the purpose of making a specific determination. None of the previous investigations have attempted to present the overall evaluation of the entire Sacramento River system.

Investigations and Reports of the Bacteriological Quality of the Sacramento River

1. Report No. 242 and Report No. 244. "To the California State Board of Health on Quality of Sacramento River Water at Sacramento". Bureau of Sanitary Engineering Report. July 28, 1920 and August 4, 1920.

The two reports presented information on the quality of water in the Sacramento River at the City of Sacramento water intake.

2. "Bacteriological Quality of the Lower Sacramento River". Bureau of Sanitary Engineering Memorandum. May 3, 1957.

The memorandum contains the bacteriological and chemical test results collected by the Bureau of Sanitary Engineering in the Sacramento River from Sacramento to the mouth of the river from 1913 to 1956. The results of approximately 50 sampling programs conducted during these years are summarized and evaluated.

3. "Progress Report on the Quality of the Lower Sacramento River Water and Domestic Sewage Effluent Discharges". Bureau of Sanitary Engineering Report. April 1957.

The report presents the bacteriological data collected during monthly sampling programs conducted in 1955 and 1956 from Sacramento to Walnut Grove.

4. "Report on City of Redding Sewage Discharge Effects on Sacramento River Water and Downstream River Uses". Bureau of Sanitary Engineering Report. May 1961.

Findings of a bacteriological sampling program carried out monthly from Redding to Butte City since 1957 are reported.

Sanitary Surveys of Domestic Water Systems. The surveys of domestic water systems made by the Bureau of Sanitary Engineering include an evaluation of the water source, the main works and distribution system, laboratory control, and the other factors that enter into a sanitary engineering appraisal of a water system. These are listed as follows:

1. "Enterprise Public Utility District Sanitary Survey". Bureau of Sanitary Engineering Report. December 9, 1953.

2. "Redding Sanitary Survey". Bureau of Sanitary Engineering Report. January 10, 1955.

3. "A Study of the Effectiveness of Alum Coagulation and Chlorination in the Redding Water Supply". Bureau of Sanitary Engineering Report. June 1959.

4. "City of Vallejo Water Supply System, Report of Sanitary Engineering Survey". Bureau of Sanitary Engineering Report. September 1959.

5. "City of Sacramento Municipal Water System". Bureau of Sanitary Engineering Report. June 1961.

Investigations Related to Recreational Use of the Sacramento River

1. "Sacramento River Survey--October, 1956". Bureau of Sanitary Engineering Memorandum. October 1956.

2. "Sacramento River Survey--September, 1960". Bureau of Sanitary Engineering Memorandum. September 6, 1960.

The recreational use of the Sacramento River from Anderson to Butte City was presented in the two memoranda.

Investigations Related to Sewage Treatment Facilities

1. "Appraisal of Red Bluff Sewage Treatment Plant Operations". Bureau of Sanitary Engineering Memorandum. August 20, 1958.

2. "Recommendations for Operating the Red Bluff Sewage Treatment Plant". Bureau of Sanitary Engineering Report. September 10, 1959.

3. Reports of plant inspections at Corning. Bureau of Sanitary Engineering "monthly notes". July 29, November 5, 1959; June 1, 1960; February 6, 1961.

4. "Report of City of Redding--Sewage Discharge Effects on Sacramento River Water and Downstream Uses". Bureau of Sanitary Engineering Report. May 1961.

5. "Sewage and Sewage Treatment of the City of Rio Vista". Bureau of Sanitary Engineering Memorandum. May 16, 1960.

6. "West Sacramento Sanitary District--Sewage Disposal Expansion Project". Bureau of Sanitary Engineering Memorandum. November 4, 1957.

7. Reports of plant inspections at Isleton, Bureau of Sanitary Engineering "monthly notes". April 9, 1958; September 30, 1958 .

The treatment facilities and the operation were evaluated in the reports and memoranda. Inspections reported in the "monthly notes of activities" were usually made at the request of the plant operator to help resolve an operation problem.

Investigations Related to Industrial Waste Discharges

1. "A Study of the Sacramento River as Influenced by Waste Discharges from the American Crystal Sugar Corporation, Clarksburg, California". California State Department of Public Health Report, 1950.

The report examined the effect of the sugar beet discharge on the oxygen content of the river.

A great deal of the sampling work, observations and inspection of conditions along the Sacramento River done by the Bureau of Sanitary Engineering has not been presented in reports. This work was generally done in conjunction with a sanitary survey of a water system, an inspection of sewage treatment facilities, or as a part of a surveillance program. The information is kept in the Bureau of Sanitary Engineering files and has been drawn upon extensively in preparing various sections of this report.

Additional References. Many related investigations have been made throughout the world and are reported in the literature. Additional references are listed at the end of this appendix. Numerals in parentheses, thus (1), refer to corresponding items in the list of references.

CHAPTER II. SURVEY AND SAMPLING PROGRAMS

Field Surveys

Three survey programs relating to public health aspects were conducted. These covered domestic water supplies, waste discharges, and recreational use of the river.

Survey of Domestic Water Supplies

The water systems which divert water for domestic use along the Sacramento River from Keswick Dam to Mayberry Slough were surveyed in order to obtain information on the quality of the diverted water. Inspections were made of each of five domestic water systems that use river water. The county health departments were contacted and information from their files regarding the systems was obtained. Also, the State Department of Public Health records were reviewed.

Survey of Waste Discharges

A survey of all waste discharges that could affect the quality of the Sacramento River was conducted. Sixteen discharges, which included municipal sewage discharges, log pond flows, industrial waste discharges, and agricultural drainage were inspected and sampled to determine the amount and type of wastes that were entering the river and to determine the characteristics of the waste that might affect the river. Extensive use was made of the records of the Central Valley Regional Water Pollution Control Board, the Department of Public Health, and county health departments.

Survey of Recreational Use

A field study of the recreational use of the Sacramento River was conducted by boat from Hamilton City to Rio Vista. The Department

of Public Health recently had conducted recreation surveys from Redding to Hamilton City and this information was used for determining recreation use in the upper section of the river.

Sampling Programs

Water quality information pertinent to the public health was obtained in four sampling programs shown on Plate 1 and described below.

Monthly Mineral Sampling Program

Samples were collected once-a-month at 22 river stations located along the main stem of the river and from each of the major discharges and tributaries. The samples were analyzed for chemical and physical properties. The program is discussed in detail in Appendix IV.

Bacteriological Sampling Program

It was felt that one sample per month from a number of stations along the river would not provide sufficiently reliable data for these considerations, therefore, intensive studies were carried out during periods when river flows and waste discharge flows were such that maximum effects would be expected. The studies were conducted during four-day periods so that sufficient data were collected for statistical evaluation.

There were several steps associated with the establishment of the four-day intensive sampling program for the collection of bacteriological data. First, the river was divided into three reaches. Sampling station locations were then selected in each reach with relation to the point of waste discharge. Finally, information on the seasonal variations in flow and quality of the waste discharges and the river was obtained so that the critical sampling periods could be scheduled.

Establishment of Sampling Reaches. The river was divided into three reaches corresponding to the reach concept discussed previously in Chapter I. The Cities of Redding and Red Bluff discharge primary sewage effluent into the upper reach of the river. It was felt that the effects of the two discharges could be properly evaluated by examining the water quality from a point above the Redding discharge to Ord Ferry, which is 60 miles downstream from the Red Bluff discharge. This stretch of river, 110 miles in length, was designated as the "upper reach". From Ord Ferry to Sacramento, a distance of approximately 120 river miles, the only major discharges are the agricultural drains. This section was designated as the "middle reach" in the intensive sampling program. The maximum use of the river for disposal of sewage and industrial wastes is made between Sacramento and Mayberry Slough, a distance of 60 river miles. The major discharges include wastes from West Sacramento, Sacramento and the surrounding area, Rio Vista, Isleton, and a large sugar beet processing plant at Clarksburg. This stretch of river was chosen as the "lower reach" for the intensive sampling program.

Location of Sampling Stations. The sampling stations for the bacteriological survey of the upper reach of the river were selected to best determine the effects of the discharges of Redding and Red Bluff. It was decided to have at least 30 samples from each station in order to obtain reliable data. To accomplish this in a four-day period meant that samples would have to be collected from each station at approximately three-hour intervals. Due to the limitations of laboratory capacity, sampling stations were restricted to 20. In selecting stations on the river, those immediately below the discharges were spaced only two or three miles apart so that the peak of the bacterial densities would be

well defined. The distance between stations then was gradually increased with the distance from the discharge. Allowing one sampling point at each discharge, there remained 18 sampling points for river stations. Nine were selected between Redding and Red Bluff, a distance of 50 river miles, and the remainder were located along the 60 river miles below Red Bluff.

In the middle reach of the river where agricultural drainage is the predominant source of waste water, there are eight major drains. Each of the drains was established as a bacteriological sampling point. This left only a limited number of river sampling stations, so that, for the most part, a river sampling station was selected immediately above each drain and at the ends of the reach.

In the lower reach of the river, sampling stations were selected close together below the effluent discharge from the City of Sacramento sewage treatment plant, the major discharge in the reach, and above and below the other discharges in the reach. In addition, samples of all sewage effluents and major accretions were collected.

In each reach samples were collected from midstream, either from boats or bridges. Locating easily accessible sampling points involved a considerable amount of field work consisting of contacting local persons in the various areas to obtain permission for access or for the use of boats and landings. A preliminary sampling program was carried out in all three reaches to determine the general range of bacteriological quality of the river water.

Selection of Intensive Sampling Periods. A preliminary investigation of the upper reach of the river from Redding to Ord Ferry revealed that the sewage discharges from the Cities of Redding and Red Bluff had

very little seasonal variations. The two towns had no canneries or other seasonal industries. The major variation of the Sacramento River bacterial quality resulting from the sewage discharges in that area would be almost directly related to the amount of flow in the river.

The flow in the river is regulated by discharges from Shasta Dam to meet the various downstream demands. During the summer months the releases closely follow the needs for irrigation waters in the agricultural areas. In June, the winter runoff has practically ceased and the water releases from Shasta Dam have not been increased to meet the summer's heavy irrigation demand. In October, the rice growing season is over and the reservoir releases are consequently greatly lowered. June and October, are, therefore, considered to be the most critical from a quality standpoint in the upper reach since these are the periods when the river flow is at its minimum. Intensive sampling programs for the upper reach were conducted during the periods June 6 to 10, 1960, and October 3 to 7, 1960.

In the middle reach of the river, from Ord Ferry to Sacramento, all diversions from the river are for agricultural uses. During the rice growing season from May to September, water is circulated slowly through the ponded fields and returned to the Sacramento River. The heaviest loading of agricultural return waters occurs in mid-September when, for a period of approximately ten days, the rice fields are drained and allowed to dry preparatory to harvesting. Also, in mid-September, releases from Shasta Dam have been reduced in anticipation of the decreased irrigation demands.

The intensive sampling programs for the middle reach were conducted from September 12 to 16, 1960, and May 8 to 12, 1961, coinciding with the periods of rice field drainage and initial flooding.

In the river below Sacramento, there are many factors involved in determining the critical period of waste loading to the river. The City of Sacramento, which is by far the major discharger to the river, has a number of large canneries contributing industrial wastes to the severage system. The canneries have two periods of peak operation. In May and June, such commodities as spinach and asparagus are processed and during August and September, tomatoes, peaches and apricots are the principal canned products. The fall canning season is the greater and the industrial flow during August and September greatly increased the volume and oxygen demand of the city's discharge. Approximately ten miles south of Sacramento, a large sugar beet processing plant at Clarksburg discharges waste water to the river during its operating season, which was from August through December in 1960. Other discharges in the area of Sacramento and downstream are primarily domestic sewage discharges and do not have a significant seasonal variation. Seasonal changes in the river flow in the lower reach are also a factor to be considered in the degree of water quality impairment. The minimum river flow at Sacramento is recorded in the fall months when the irrigation season is over and releases from Shasta Dam are reduced to a minimum. Accordingly, the sampling periods in the lower reach of the river were June 20 to 24, 1960, August 29 to September 2, 1960, and October 24 to 28, 1960.

Methods of Sampling. There were two methods used to obtain the river water samples for bacteriological analyses. In all cases samples were collected from the center of the main flow of the river and the procedures for care and handling of samples described in the 10th edition of "Standard Methods for the Examination of Water, Sewage and Industrial Wastes" were followed. At the relatively few bridge stations, the sample bottle was

lowered on a string to the river. At river stations where boats were used to reach the center of the stream, the boat was turned upstream and the collector dipped the sample bottle in a sweeping arc moving upstream.

Transportation. Two-man crews were responsible for the collection of samples at each set of three or four stations. Because of the distances involved, it would not have been possible for each crew to deliver samples to the laboratory and still maintain their sampling schedule; therefore, one man was given the assignment of meeting the sampling crews at some convenient point and collecting their samples for transfer to the laboratory. This entailed a very close time schedule for the operation. The "pickup" man met each crew at approximately six-hour intervals after the crew had completed two circuits of their stations. The time interval between collection of sample and commencement of the analyses at the laboratory generally ranged from several minutes to slightly over six hours. During this period, samples were stored in ice chests.

Laboratory Facilities. The necessity of analyzing bacteriological samples in as short a time after collection as possible has been established by numerous studies of the effects of storage on the bacteriological content of water (1). In order to begin the bacteriological analyses as soon as possible after collection, a mobile laboratory of the State Department of Public Health was moved to the survey area to perform the analyses. The mobile laboratory is a converted house trailer equipped with twin incubators having a maximum capacity of 6,400 fermentation tubes, a pressure cooker for sterilizing sample bottles, washing facilities, storage space, and work areas for performing the required bacteriological analyses. The laboratory was towed by a two-ton truck that carried

all the glassware, media, and other equipment necessary to make the laboratory an independent unit.

The Red Bluff sewage treatment plant was chosen as the laboratory site for sampling of the upper reach. The site was approximately at the midpoint of the upper reach. Running water, electricity, and nearby housing facilities were available at this location.

For the middle and lower reach sampling programs, the mobile laboratory was located at the Bryte water chemistry laboratory of the Department of Water Resources. This is west of Sacramento, at the boundary of the middle and lower reaches. It was within a reasonable travel time of the sampling points along the two reaches and had the desirable features of having both the chemical and bacteriological laboratories at the same location.

Prior to any sampling, meetings were held with members of the Sanitation and Radiation Laboratory of the Department of Public Health to determine the number of bacteriological water samples that could be handled daily by the mobile laboratory and the procedures to be used in collection, transportation, and identification of the samples. A number of samples were collected at various points along the river on a preliminary sampling run. The results were used by the laboratory to assist them in planning for the subsequent intensive studies.

Monthly Plankton Sampling Program

Plankton samples were collected monthly at stations along the main stem of the Sacramento River.

Organic Sampling Program

Early in the planning stages of the survey it was decided to include an organic sampling program using the carbon adsorption technique

in order to obtain information on the present levels of organic material in the Sacramento River. Such programs have been carried out as part of an over-all monitoring program on other major rivers of the country to provide measures of the organic pollution. It is expected that the best use of the information obtained in the organic sampling program on the Sacramento River will lie in the future when the present levels of organic material in the river can be compared with future levels.

At the present time, little is known of the limits of organic material that are undesirable or harmful in a water supply. It has been found that when a water supply has a concentration of chloroform extractable material higher than 200 parts per billion (ppb), taste and odor problems may be anticipated.

Certain insecticides have been reported to be toxic to fish in minute concentrations as shown in Table 1. The tabulated data are included herein not as criteria for limiting concentrations in water, but as an indication of the ranges of toxicity of the various insecticides.

TABLE 1

TOXICITY OF CERTAIN INSECTICIDES TO FISH (2)

Insecticides	96-Hour TL_m (median tolerance limit) ppb (micrograms/liter) active agent		
	Fathead Minnows in soft water	Fathead Minnows in hard water	Guppies in soft water
Chlorinated Hydrocarbon			
BHC	2300	2000	2170
Chlordane	52	69	190
DDT	32	34	43
Endrin	1.0	1.3	1.5
Lindane	62	56	138
Toxaphene	7.5	5.1	20
Organic Phosphorus			
EPN		0.25	
TEPP		1.0	
Systox		4.2	
Malathion		12.5	
Dipterex		51	
OMPA		135	

With the present trend toward increased use of organic chemicals in agriculture, industry, and even the home, information obtained from the organic sampling program is expected to be valuable in preventing pollution of the Sacramento River by organic material in the future.

Sampling Equipment and Technique. The sampling apparatus used in the Sacramento River Study is shown in Figure 1. The major components are: a pump and pressure tank, sand filter, carbon filter, flow meter

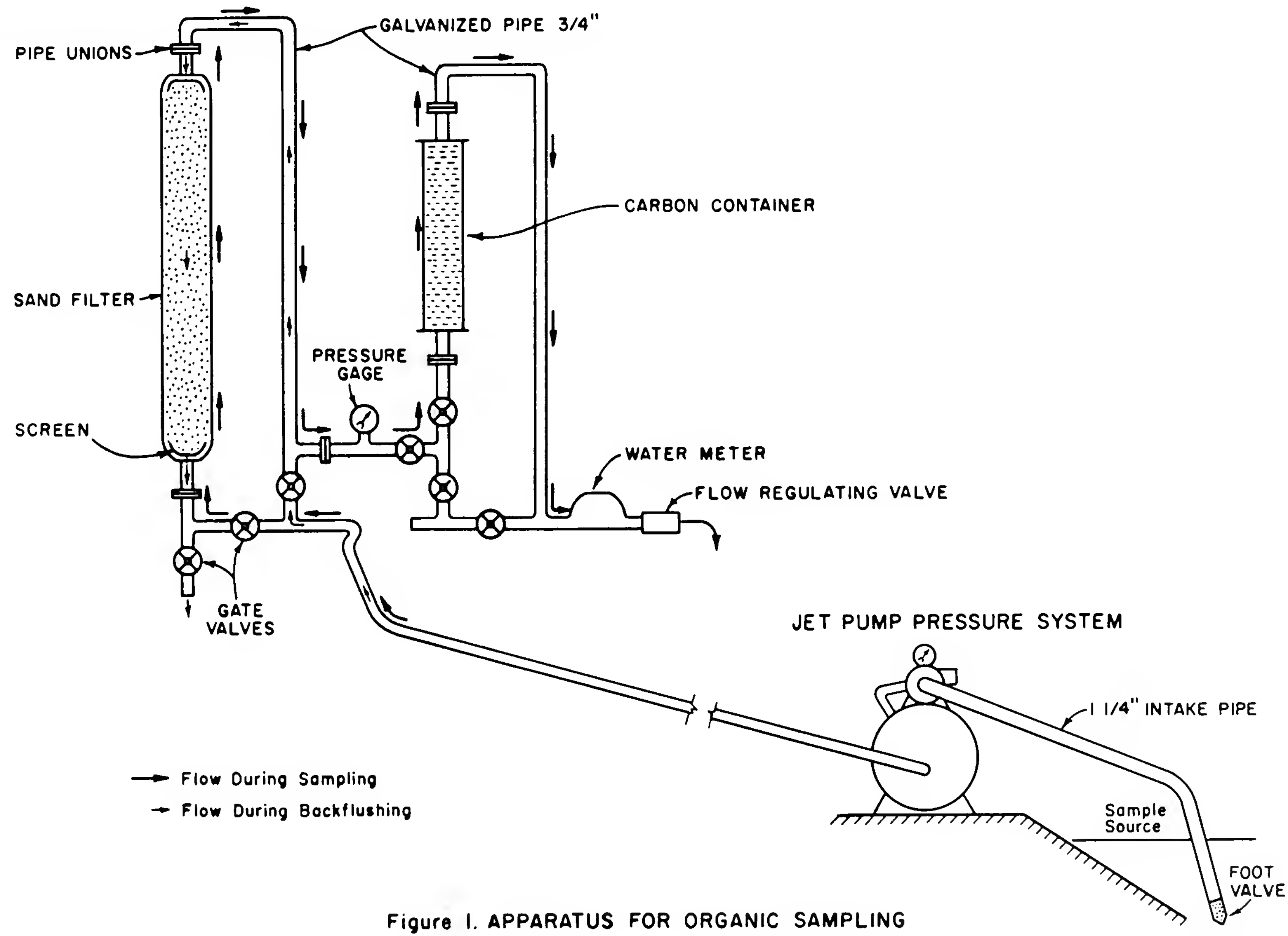


Figure 1. APPARATUS FOR ORGANIC SAMPLING

and flow regulating valve. The piping and valves are located so that the sand filter may be "backflushed" when the differential pressure across the filter indicates that the medium has become clogged. The flow regulating valve maintains the desired flow of 1/2 gallon per minute through the carbon filter and the meter records the total flow that has passed through the apparatus.

Approximately 5,000 gallons of water were passed through the filter in order to obtain sufficient adsorbed material on the carbon for analysis.

Description of Sampling Program. The organic sampling program called for sampling at five stations on the river, a station on a major agricultural drain, and stations on the supply and drain from a typical rice field.

The most upstream station was located at Keswick Dam. There are no waste discharges above the dam other than mine drainage from Spring Creek which would have little, if any, effect on organic quality of the river; therefore, the station at Keswick is believed to yield the base level organic quality of the river.

Hamilton City was selected as the next downstream river site. The findings at this station would show the effects due to discharges that enter the river from Keswick Dam to Hamilton City; the Redding and Red Bluff sewage discharges, industrial water from a paper mill and a few minor log pond overflows.

Agricultural drainage water is discharged to the river through a number of large drains and sloughs located between Hamilton City and Sacramento. Station sites above the Colusa Basin Drain and at Bryte near

Sacramento were selected to determine the increase in the organic content of the river caused by the drainage water.

A sampling station was located on the Colusa Basin Drain to determine the organic material in the drainage water.

Walnut Grove was selected as the site of the final river sampling station. This is near the Delta Cross Channel on the lower end of the river where water is diverted for export to the San Joaquin Valley and near where water will be diverted to southern California under The California Water Plan. The organic analysis of the water from this station would reveal the increment of organic pollution due to the sewage discharges in the Sacramento area and the industrial discharge at Clarksburg.

The rice field area selected was a 55 acre plot in the northwest corner of Sacramento County. The supply and drainage water was sampled during the 1960 growing season so that the relationship between insecticide application and drainage quality could be determined.

The dates on which samples were collected at the stations are given in Table 2. A total of 27 samples were collected. One was lost in the laboratory and one was voided due to an unreliable sample source.

Laboratory Facilities. Arrangements were made for the analyses to be conducted by the State Department of Public Health, Division of Laboratories at Berkeley. All analyses were performed at Berkeley except three (one of which was a duplicate sent to both laboratories) which were sent to Terminal Testing Laboratory in Los Angeles.

Table 2

ORGANIC SAMPLING PROGRAM
SAMPLING PERIODS

River Stations	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
Sacramento River at Keswick Dam			9-26-60 10- 7-60		11-14-60 11-23-60		1-12-61 1-20-61		3- 2-61 3- 9-61		5- 2-61 5- 8-61	
Sacramento River at Hamilton City		8-14-60 8-26-60			11-15-60 11-29-60						5-23-61 5-30-61	
Sacramento River above Colusa Basin		8-16-60(Void) 8-25-60		10-13-60 10-23-60			1- 4-61 1-11-61			4- 5-61 4-12-61		6-21-61 6-26-61
Sacramento River at Bryte Laboratory	7-12-60 7-26-60		9- 3-60(lost) 9-19-60		11-12-60 12- 2-60			2-17-61 2-24-61		4-20-61 4-27-61		6- 6-61 6-14-61
Sacramento River at Walnut Grove				10-25-60 11-12-60						4-29-61 5- 4-61		6- 7-61 6-13-61
Special Study Stations												
El Centro Rice Field Drain	6-24-60 7- 4-60											
Supply	7-11-60 7-20-60											
Colusa Basin Drain		8-15-60 8-26-60	9- 5-60 9-20-60								5-20-61 5-25-61	

Note: Dates indicate beginning and end of particular sampling period.

CHAPTER III. LABORATORY TESTS AND THEIR SIGNIFICANCE

Chemical Analyses

A detailed discussion of the methods used in the chemical analyses of the water samples is presented in Appendix B, Water Quality.

Bacteriological Analyses

Samples of the Sacramento River water and the waste discharges were analyzed for coliform and "fecal" coliform bacteria. Discussions of coliform organisms are included in standard references. The concept of "fecal" coliform organisms and the fairly recently developed differential test for their presence used in this study are not as well known. Analyses for "fecal" coliform organisms were carried out in order to investigate the possibilities of using the differential test as a more precise indicator of fecal contamination.

Coliform Bacteria

The coliform bacteria group includes all of the aerobic and faculative anaerobic gram-negative nonspore-forming bacilli which ferment lactose with gas formation within 48 hours at 35°C. Table 3 shows the various types of coliform bacteria and their probable habitat.

Table 3

COLIFORM BACTERIA AND PROBABLE HABITATS

(From the Bacteriological Examination of Water Supplies No. 71 of Reports on Public Health and Medical Subjects, Ministry of Health, 1939.)

Coliform Type	Probable Habitat
E. Coli, Type I, (Faecal)	Human and animal intestine
E. Coli, Type II	Doubtful, probably not primarily intestinal
Intermediate, Type I	Mainly soil
Intermediate, Type II	Mainly soil
A. Aerogenes, Type I	Mainly vegetation
A. Aerogenes, Type II	Mainly vegetation
A. Cloacae	Mainly vegetation
Irregular, Type I	Human and animal intestine
Irregular, Type II	Doubtful
Irregular, Other Types	Doubtful

Coliform bacteria are found in far greater numbers in domestic sewage than pathogenic bacteria. Their death rate is comparable to that of the pathogens and since the test for coliforms is sensitive enough to detect a few organisms in 100 milliliters of water, an absence of coliform organisms is a good, sensitive indication of an absence of pathogenic bacteria. A major reason for using this indirect method in place of demonstrating directly the presence of pathogenic organisms, is the relative simplicity of the coliform test as compared to the technical difficulties involved in isolating specific pathogens. The chief drawback to the routine coliform analysis is that the types of coliforms generally not associated with sewage will also show positive results and may give a false indication of fecal contamination.

The routine test for coliform bacteria consists of fermentation tests based on ability of the bacteria of this group to produce gas in a media containing lactose. The results of the fermentation tests are expressed in terms of MPN, the Most Probable Number of coliform organisms per unit volume.

Fecal Coliform Bacteria

The types of coliform bacteria in Table 3 can be differentiated by means of a series of time consuming tests known as the IMViC reactions. In order to differentiate between the so-called fecal and nonfecal coliforms without resorting to the IMViC tests, several types of selective media have been proposed that tend to inhibit the growth of bacteria of nonfecal origin without inhibiting the growth of fecal coliform. Culture media developed by Eijkman, MacConkey, and the bile salt medium of Hajna and Perry (EC medium)[3] are the three media which tend to accomplish this selectivity with some degree of success when used at higher incubation temperature (about 45°C). When such differentiation is desired, these media are generally used to replace the brilliant green lactose broth in the confirmatory test. Geldreich and others [4] conducted a study in 1958 to determine the selectivity of the EC medium. Coliform cultures of 12 IMViC types were incubated in standard lactose broth for 48 hours at 35°C. Transfers from positive tubes were made to EC broth which were incubated at 45.0°C ± 0.3°C. E. coli Type I and E. coli Type II gave positive EC reactions in, respectively, 93 and 22 percent of the cultures. The other 10 types which are usually considered of nonfecal origin gave only 8 percent positive reactions in EC media.

The U. S. Public Health Service has recently conducted and directed studies in shellfish research which have included evaluations

of the EC confirmed test (5,6). The relationships between EC positive tubes and the presence of E. coli Type I were investigated in several studies with sea water, and from 92-95 percent of EC gas positive tubes at 45.5°C were found to contain E. coli Type I.

In summary, studies have shown that the EC medium when used in the confirmatory test at higher incubation temperatures indicates the presence of E. coli Type I and II with a fair degree of reliability while generally suppressing other coliform organisms.

The term "fecal coliform" used in this study was a label given to the bacteria which produced gas in EC medium in the confirmatory test at 44.5°C. The term is perhaps not the best to describe these organisms, but it has been used before, and is convenient. It is important to keep the definition in mind and realize that the term is more relative than absolute.

Method of Analysis

All bacteriological analyses were performed by chemists and bacteriologists of the Sanitation and Radiation Laboratory of the Department of Public Health under the direction of the supervisor of the Bacteriological Section. A total of four to six persons were required to perform the analyses during each of the intensive sampling periods. The analysis for coliform bacteria was performed in accordance with the procedures set forth in the 11th edition of "Standard Methods for the Examination of Water and Wastewater". Five fermentation tubes of each of at least three decimal dilutions were inoculated and incubated for 24 ± 2 and 48 ± 2 hours at 35°C ± 0.5°C. Transfers from the tubes showing gas were made to brilliant green lactose bile broth and incubated for 48 ± 2 hours at 35°C ± 0.5°C in accordance with "Standard Methods".

Transfers from all gas positive presumptive tubes also were made to fermentation tubes containing EC medium and which were incubated in a water bath at 44.5°C ± 0.3°C for 48 ± 2 hours. This parallel differential test was performed to determine the number of "fecal" coliform organisms in the sample. The different incubation temperature and the closer temperature control involved necessitated the separate water bath type incubator for these tubes. Due to limitations of water bath space, only half of the samples collected at each sampling station were analyzed for fecal coliform.

Plankton Analyses

The term plankton, as used in this report, designates microscopic and near-microscopic free-floating organisms irrespective of their origin. Organisms ordinarily growing along the shore or at the bottom, when detached and floating freely in the water are included as are those organisms indigenous to the water mass. Excluded from the plankton are bacteria and higher plants and animals. Typically, the term plankton covers such plant groups as Chrysophyta (diatoms), Chlorophyta (green algae), Cyanophyta (blue-green algae), and Euglenophyta; and, among the animals, the Protozoa, the Rotifera, the Crustacea, and the Nematoda.

Ground waters seldom, if ever, have plankton in them. Surface waters, on the other hand, usually contain plankton organisms which may complicate the provision of a potable water. Some problems are taste and odor, filter clogging, water blooms, and toxicity. "Standard Methods for the Examination of Water and Wastewater"[7] presents an inclusive list of reasons for the biological examination of water, as follows:

"a. To explain the cause of color and turbidity and the presence of objectionable odors and tastes in water and to

indicate possible methods for their prevention or removal.

b. To aid in the interpretation of the various chamical analyses, as, for example, in relating the presence of biologic forms to oxygen deficiency or supersaturation in natural waters.

c. To identify the source of a water that is mixing with another.

d. To explain the clogging of pipes and filters and to aid in the design and operation of water works.

e. To indicate pollution by sewage or industrial wastes.

f. To indicate the progress of the self-purification of streams and other bodies of water.

g. To aid in explaining the mechanism of biologic sewage treatment methods or to serve as an index to the effectiveness of the treatment.

h. To aid in the study of the ecology of fish, shellfish, and other aquatic organisms. To obtain information on food, parasites, and other factors affecting the well-being of these forms.

i. To determine whether or not ground water is contaminated by unfiltered surface water.

j. To determine optimum times for treatment of raw surface water with algicides and to check on the effectiveness of such treatment.

k. To determine, within the water plant, the effectiveness of various stages in the treatment of water."

While all of these objectives are not pertinent to this study, many of them obviously are.

A plankton identification scheme modeled after that used by the U. S. Public Health Service, National Water Quality Network [8], was used. This was based on generic or genus-type identification with the assignment of all organisms to a larger group for counting purposes. The groups used were: blue-green algae, coccoid or filamentous; green algae, coccoid or filamentous; flagellates, pigmented or unpigmented, diatoms, centric or pennate; protozoa, amoeboid or ciliated; rotifers; crustacea, and nematodes. This classification is based on major taxonamic groupings and organism morphology within the major groupings.

Method of Analysis

Preserved samples (160 ml formalin per gallon) were delivered to the laboratory and stored in the dark at refrigerator temperatures until analyzed. Analysis proceeded in two steps: 1) concentration and 2) microscopic examination.

Concentration. Samples were concentrated by means of a Foerst electric centrifuge. This is a continuous flow centrifuge which operates at a fixed speed of about 15,000 RPM. The rate of flow through the centrifuge was adjusted to approximately 175 ml per minute. The typical sample aliquot taken for concentration was one liter. The concentrate was adjusted in volume to 25 ml and stored until examined microscopically.

Preliminary trials with the centrifuge indicated that recovery of plankton with a single pass of the sample yielded incomplete recovery. Two passes, however, removed at least 95 percent of the suspended material, consequently, all samples were passed through the centrifuge twice.

Microscopic Examination. A 1.00 ml aliquot of the well-mixed, concentrated sample was pipetted into a Sedgwick-Rafter cell and a cover slip was floated on. The inside dimensions of the cell were 19.5 x 50 x 1 mm deep.

Cell examination was made first under a stereoscopic dissecting microscope with a magnification of 25 X. All organisms larger than 30 microns were noted and recorded. The cell was then examined with a standard binocular microscope equipped with a 10 X ocular containing a previously calibrated Whipple ocular micrometer and a 21 X objective lens. The total magnification was 210 X. The kind, number and size of plankton forms in each of 20 fields was recorded on an appropriate work sheet.

To obtain the number of organisms per ml, the following calculations were necessary:

$$\text{Factor} = \frac{\text{number of fields in cell}}{\text{number of fields counted}} \times \frac{\text{ml concentrate}}{\text{ml original sample}}$$

$$= \frac{\frac{19.5 \times 50}{(0.5122)^2}}{20} \times \frac{25}{1000}$$

$$= 4.6$$

From the number of organisms enumerated in 20 fields, the number of organisms per ml was obtained:

plankton per ml = number of organisms in 20 fields x factor

= number of organisms in 20 fields x 4.6

To obtain information on the mass of plankton, that is, the area occupied by the plankton, the recorded data on plankton size, in terms of areal standard units (an areal standard unit is 400 square microns), was multiplied by the same factor as above:

areal standard units per ml = number of standard units in 20 fields x factor

= number of standard units x 4.6

Carbon Adsorption Method Analyses

Analyses of organic material collected by carbon filter apparatus are more appropriately designated by the term "Carbon Adsorption Method (CAM) for Organics in Water". Basically, the procedure is to pass the water sample over activated carbon which has a relatively high adsorptive capacity for organic materials. Following removal of the carbon from the sampling assembly, the carbon is dried and sequentially extracted with chloroform and ethanol. The chloroform extract is subsequently separated into fractions based on differential solubility and chromatography.

The objective of this procedure is to isolate all of the organic materials present in the water. Unfortunately, only an unknown fraction of the total organics in water is measured. It has been shown, by working with known organic materials, that adsorption may be close to one hundred percent, and that desorption, under the conditions of the test, may range from 50 to 90 percent. In working with natural waters, it is impossible, however, to determine how much of the organic material is adsorbed on the carbon or how much of the adsorbed organic material is extracted from the carbon. The U. S. Public Health Service (8) estimates that the sampling and analytical techniques are reproducible to within ± 10 percent when applied to replicate samples. For this reason, this technique is best suited to the measurement of relative pollutional loads on streams.

The results obtained by the National Water Quality Network of the U. S. Public Health Service (8) have shown that clean waters may contain between 20 and 50 ppb of chloroform extractables and 50 to 100 ppb

alcohol extractables. Polluted waters, on the other hand, may contain several times these concentrations.

In order to make more meaningful the discussion of the organic materials which are recovered by these techniques, it would be helpful to first present the analytical methods themselves.

Methods of Analysis

The analytical method developed by Braus, Middleton, and Walton[9] modified by subsequent work at the Robert A. Taft Sanitary Engineering Center [10], and the State Department of Public Health, was used. The method may be summarized as follows:

1. The dried carbon was sequentially extracted with chloroform and ethanol and the separate extracts were weighed. Solvent removal and drying are critical operations, and, to obtain reproducible results, the procedures must be followed exactly. Initial solvent removal was on a steam bath maintained at a temperature below the boiling point of the solvent. Filtered, dried air was passed over the extract to hasten evaporation. After solvent odors were no longer detectable, the extracts were dried under infrared lamps for five minutes, cooled, and weighed.

   Results are reported as parts per billion (ppb) chloroform or alcohol extractables.

$$ppb = \frac{\text{grams of extract} \times 10^6}{\text{gallons of water} \times 3.785}$$

2. The chloroform extract was further fractionated in accordance with the scheme shown in Figure 2. The six major fractions -- ether insolubles, water solubles, amines, strong acids, neutrals, weak acids -- are each reported in ppb.

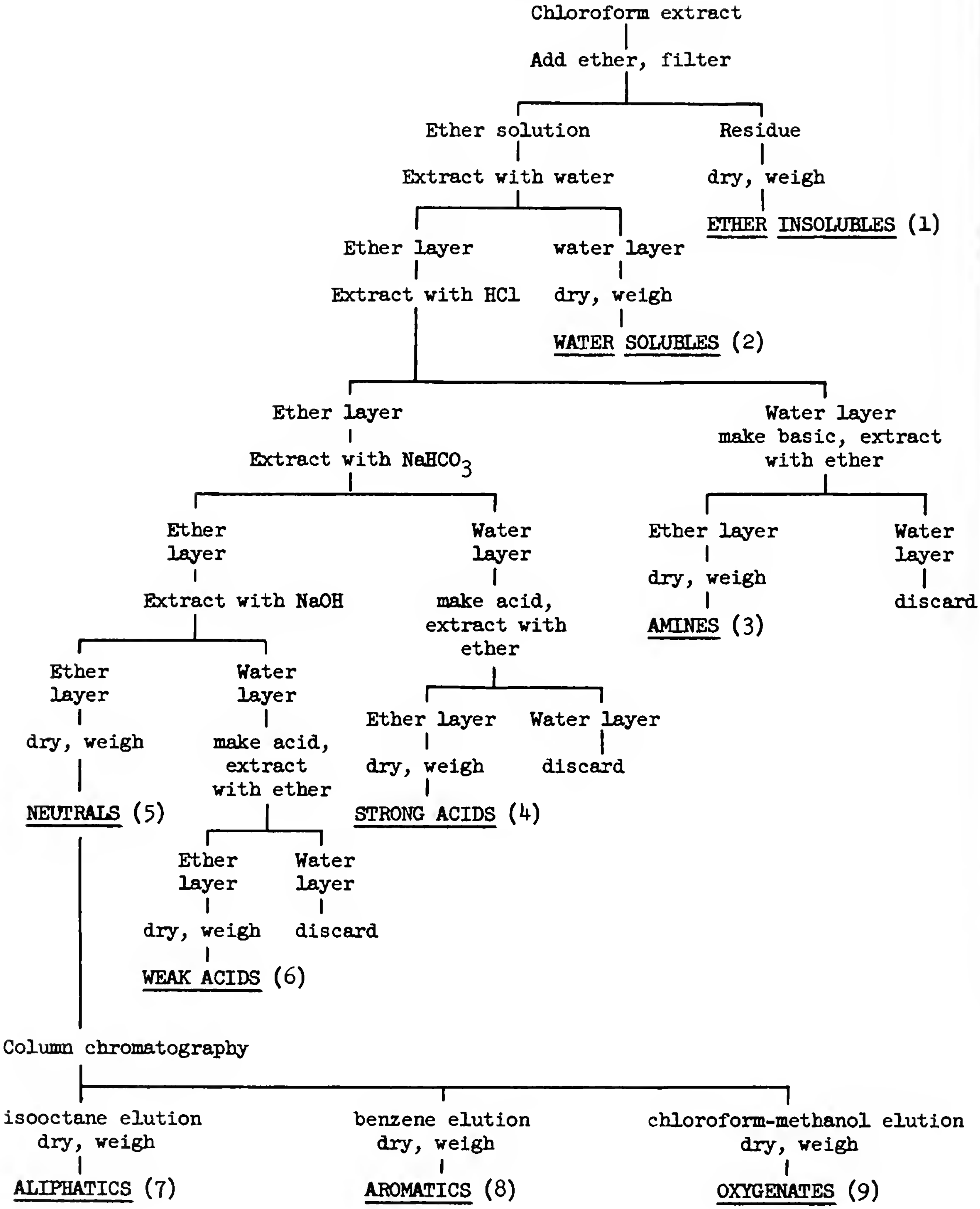
The difference between the sum of the fractions and the initial amount of chloroform extract is reported as loss. As a result of the number of manipulation involved in the separations and the partition coefficients of the solutes, losses may be appreciable.

The neutral fraction was additionally fractionated by column chromatography yielding aliphatics, aromatics, and oxygenates. As before, the difference between the sum of these fractions and the initial amount of neutral fraction is reported as loss.

3. The infrared spectra of the chloroform and alcohol extracts and the nine fractions of the chloroform extract were determined in the range from 2 to 15 microns by means of an infrared spectrophotometer.
4. All extracts and fractions were placed in tightly sealed glass vials for permanent future reference.

Figure 2

SCHEMATIC ANALYSIS OF CHLOROFORM EXTRACT



Significance of Results

Mention has been made in Chapter II of the taste and odor problems which may be associated with certain organics. Mention was also made of the toxicity of organic chemicals to fish. From the point of view of human health, little is known of the possible immediate or long term effects of these materials.

The U. S. Public Health Service [8] has published a valuable summary on the significance of the various fractions of organic compounds which may be found in water. The following material is based on that summary:

I. Chloroform Extract

The organic material included in chloroform extract is extremely complex. Direct interpretation of the results from a qualitative point of view is practically impossible. More significance, however, can be attributed to the various fractions of the chloroform extract.

A. Ether Insolubles

This material is usually a brown humus-like powder apparently composed, to a large extent, of carboxylic acids, ketones, and alcohols of complicated structure. The material is considered to be an indicator of "old" pollution which has its origin in partially oxidized sewage and industrial wastes. Streams with little or no history of pollution have little or no ether insoluble materials.

B. Water Soluble Materials

These substances are largely acidic materials of low molecular weight. Probably included in this group

are hydroxy-acids, keto-acids, and keto-alcohols. The origin of this material is probably from partially oxidized hydrocarbons. There is little odor associated with the water solubles.

C. Weak Acids

The best known of the weak acids is phenol which is frequently involved in taste and odor problems, particularly where industrial wastes are discharged to a stream. Other weak acids are enols, imides, sulfonamides, and some sulfur compounds. Materials of this group also occur in nature.

D. Strong Acids

These acids are usually the carboxylic acids such as acetic, benzoic, salicylic, or butyric. Many of these acids are used industrially, but they may also be produced by natural processes such as fermentation. While some of these materials are highly odorous, their significance can be interpreted only in the light of stream pollution conditions.

E. Amines

This group includes organic amines such as aniline, and pyridine, which are of commercial importance. Lower amines may occur as a result of decomposition. Amines are frequently odorous, however, the low concentrations which are usually found are not likely to cause objectionable conditions. In the instance of wastes which contain amines, this group may be of considerable significance.

F. Neutrals

The neutral group frequently constitutes the major portion of the chloroform extracts. These materials are less reactive and tend to persist in streams longer than many other types of organic materials. Among the more important examples of neutrals are hydrocarbons, aldehydes, ketones, esters, and ethers.

1. Aliphatics

   This portion of the neutral group represents petroleum-type hydrocarbons. It is usually composed of mineral oil types of compounds. The most likely sources of aliphatics are petroleum and petroleum wastes.

2. Aromatics

   These are principally the coal tar hydrocarbons such as benzene, toluene, and other cyclic organic compounds. The presence of this group is any significant amount is a reliable indication of industrial and/or agricultural pollution. These materials are highly odorous and possibly may be toxic, since a number of the insecticides which are widely used in agriculture belong to the aromatic fraction.

3. Oxygenates

   This group includes neutral compounds which contain oxygen such as aldehydes, ketones, and esters. They may have originated by direct discharge or may represent oxidation products from both

natural and industrial materials. They help to indicate "age" of the pollution, since pollution exposed to oxidation forces for a long time would be expected to contain large amounts of oxygenates. These substances are odorous.

II. Alchol Extract

The alcohol extractable material generally consists of more polar substances than the chloroform extract and includes such compounds as synthetic detergents, proteins, carbohydrates, and miscellaneous natural substances.

In waters with mixed industrial and domestic pollution, the chloroform and alcohol extracts may be of equal magnitude. In some streams where the industrial pollution is rather low and much natural or sewage pollution is present, the alcohol extract may exceed the chloroform extract by a factor of 4 to 6. In the program of the U. S. Public Health Service, it has been found that one to two percent of the alcohol fraction is made up of synthetic detergents.

CHAPTER IV. WATER QUALITY AND THE PUBLIC HEALTH

The public health interests in water quality are manifold, since many of the physical, chemical, and biological properties of water determine its suitability for drinking, recreation, and the preparation or growing of foodstuffs.

Man's drinking water must be free of disease-producing organisms and chemical substances that are harmful. It should be cool, clear, and free of odors and tastes. It should be suitable for all household purposes such as culinary use and the washing of clothes. Domestic water should not stain, corrode, or foul pipes or plumbing fixtures.

Waters used for aquatic sports must be safe not only from the standpoint of disease transmission but also reasonably free of accident hazards. Clarity of recreational waters should be such that submerged logs and rocks are visible to bathers, and not so turbid that swimmers and divers cannot be readily seen by lifeguards.

Food crops must not be contaminated by waters used for their irrigation. The foodstuffs which are usually eaten raw are of particular concern if they should be wetted by water which has been contaminated by sewage. Water used in the processing of foods also must be free of filth and disease-producing organisms.

Devastating epidemics of typhoid and other "water-borne" bacterial diseases are now a matter of history in the United States, due to the application of knowledge, continuously growing, in the sanitary sciences and preventive medicine. In large part, the near eradication of "water-borne" bacterial diseases is due to progress in water purification and pollution prevention, control, and abatement. The threat of "water-borne" disease, however, will persist as long as wastes from the

human body are placed where they may find their way into man's sources of water.

At the present time, increasing attention is being directed toward viruses and the role water and sewage may play in transmission of virus diseases. Within the past few years about 75 enteroviruses, those found in the intestinal tract and sewage of man, have been identified, though not all have yet been associated with specific diseases. It is known that conventional water treatment practices are not sufficient to destroy certain of these viruses which are found in human excreta. Of particular concern is the virus of infectious hepatitis. Overwhelming evidence has established that this disease can be "water-borne", but laboratory methods have not yet been found to isolate the causative organism of this disease. Until laboratory techniques have been developed which will ascertain the type and degree of treatment that is necessary to destroy hepatitis, control must depend on judgements based on experience.

Also of concern is the presence of the new types of chemicals in sewage, industrial wastes, and land drainage. Typical of these new contaminants resulting from our dynamic industrial technology are radioisotopes, synthetic detergents, and pesticides. Accurate laboratory methods have not been developed to identify or measure the amounts of most of these new chemicals that now may be reaching our waterways. Some of the synthetic organic chemicals do not break down in receiving waters, nor are they removed by normal sewage or water treatment methods. The subtle and long-range effects of these new chemicals on the public health must be learned, and threshold limits established. Until this is done, policies must necessarily be conservative.

The common mineral constituents in water originating in the geological formations through which the water passes and, frequently,

from agricultural waste waters, are also of public health concern. High levels of sodium cannot be tolerated by people suffering from certain heart and kidney diseases, and by many pregnant women. Such people must carefully limit their total sodium intake, including that portion contributed by their drinking water. Natural waters high in sodium are not often suitable for such people, and alternate water sources are necessary. Excessive amounts of fluorides in water will have major detrimental effects on the physical structure of teeth of children drinking such waters. In addition to these, and possibly other adverse physiological effects, waters high in total minerals (including chlorides, sulfates, and magnesium) have a brackish, salty or bitter flavor, and at higher levels are most unpalatable and therefore unacceptable to the public. Flavor of water is of particular significance since the State Board of Public Health, in granting permit for domestic water supply, must find that the water delivered will, among other things, be wholesome and potable. Only costly demineralization processes will remove such undesirable common minerals.

In addition to the ideas already expressed, the following are axioms that are fundamental to the public health interest in water quality.

1. In order to serve the widest range of human needs, the waters of the State must be maintained as clean as possible.(11)
2. It should be the responsibility of the water user to return the water as clean as it is technically possible.(11)
3. Beneficial uses of a water must not be destroyed, or even seriously impaired, by a waste discharge.
4. Pollution and contamination are best dealt with at the sources. Treatment of a seriously degraded water even in those cases where possible, and quarantine of contaminated

areas, are undesirable alternatives to prevention of water degradation.

5. The most complete and efficient types of sewage treatment utilized today do not, of themselves, produce from sewage, water that is restored to its original quality. Natural purification and dilution afforded by receiving waters must be available to further reduce concentrations of undesirable constituents. Moreover, on esthetic grounds, the public demands a separation of time and distance between waste discharge and water use.
6. Singular dependence on water treatment or sewage treatment should be avoided. For a high degree of public health protection, there must be reliable and effective treatment of both sewage and water.
7. Water and sewage treatment are not infallible. Treatment processes for both water and sewage are subject to mechanical failure and human error.
8. Sudden and unexpected changes in raw water quality are likely to upset water treatment processes to a degree such that the plant may fail to produce an acceptable quality water.
9. With relation to many taste- and odor-producing substances, seriously degraded waters usually cannot be returned to a high quality condition by even the most complete water treatment processes generally utilized.
10. A water quality management program, to be successful, must be based on engineering studies and evaluations of all

pertinent factors influencing water quality, supplemented by sampling programs of effluents and receiving waters.

It is not practicable to keep all wastes out of waters. It is, however, practical to require maximum possible treatment of wastes discharged to usable waters. A complementing program of health safeguards through adequate water treatment makes possible the maintenance of a high level of water quality in all the waters of the State.

The U. S. Public Health Service Drinking Water Standards of 1946 are used as a quality standard for public water supplies in California. The Drinking Water Standards include maximum allowable and maximum suggested values for physical, chemical, and bacteriological qualities of the water. The 1946 standards [12] and the 1962 chemical standards are summarized in Table 4.

Table 4

CHEMICAL LIMITS
U. S. PUBLIC HEALTH SERVICE DRINKING WATER STANDARDS

	Recommended Maximum Limits (1) (milligrams per liter)		Concentrations which constitute grounds for rejection of supply (milligrams per liter)	
	1946	1962	1946	1962
Alkyl benzene sulfonate (Detergent)	-	0.5		
Arsenic	-	0.01	0.05	0.05
Barium			-	1.0
Cadmium			-	0.01
Carbon chloroform extract (exotic organic chemicals)	-	0.2		
Chloride	250.	250.		
Chromium			0.05	0.05
Copper	3.0	1.0		
Cyanide	-	0.01		0.2
Fluoride	-	(2)	1.5	(2)
Iron + manganese	0.3	-		
Iron	-	0.3		
Lead			0.1	0.05
Manganese	-	0.05		
Nitrate	-	45.		
Phenols	0.001	0.001		
Selenium			0.15	0.01
Silver			-	0.05
Sulfate	250.	250.		
Total dissolved solids	500.	500.		
Zinc	15.	5.		

(1) Concentrations in water should not be in excess of these limits, when more suitable supplies can be made available.
(2) Maximum levels of fluoride concentrations are related to average air temperatures. See text of proposed standards.

In determining the degree of treatment required for any particular source of domestic water, major dependence lies with the sanitary evaluation of the watershed; however, raw water quality guides are a useful tool in the evaluation. Based on the operating records of Ohio River water treatment plant, Streeter has proposed a guide for the maximum degree of coliform bacteria that can be accepted by various water treatment methods if the treated water is to meet the standards of the U. S. Public Health Service (13). The 1946 guide is presented in Table 5.

Table 5

RAW WATER BACTERIOLOGICAL LIMITS FOR VARIOUS TYPES OF WATER TREATMENT

Monthly Average Coliform MPN/100 ml	Limits of Variability	Treatment Method
50	None	Chlorination
5,000	Not more than 5,000/100 ml in more than 20% of monthly samples.	Filtration and Postchlorination
5,000	More than 5,000/100 ml in more than 20% of monthly samples but not more than 20,000/100 ml in more than 5% of monthly samples	Presedimentation, prechlorination or their equivalent, filtration and postchlorination.
More than 5,000	None	Prolonged preliminary storage or other reliable measures in addition to prechlorination, filtration and postchlorination.

The State Board of Public Health has not yet adopted bacteriological standards for irrigation water, except those in the board's regulations governing the direct use of sewage effluents for crop irrigation. Also, no bacterial standards have been established for fresh

water recreation areas. The present bacteriological methods of water analyses can not in themselves be used to evaluate its safety for recreation or irrigation. Bacteriological quality is an important parameter, but the acceptance or rejection of a water for irrigation or for water-contact sports must depend on a complete sanitary engineering appraisal of all factors influenceing water quality.

CHAPTER V. BACTERIOLOGICAL QUALITY

History

There is very little data available on the bacteriological quality of the entire Sacramento River before 1951. In April of that year a statewide monthly stream sampling program was initiated at the request of the State Water Pollution Control Board and six sampling stations were established on the Sacramento River from Keswick Dam to Rio Vista. Before the stream sampling program was established, virtually all bacteriological sampling was limited to the area from Sacramento to Rio Vista and was carried out to determine the degree of contamination caused by the waste discharges at and below Sacramento.

Although bacteriological results are not available above Sacramento before 1951, a fair indication of the water quality can be pieced together from descriptions of conditions in sanitary surveys and miscellaneous reports. In the early 1900's, summer resorts, lumber camps, individual residences, and many small communities were discharging raw sewage or septic tank effluent into the Sacramento River above the present site of Shasta Lake. In 1916, officials of the City of Redding declared that the river near the city was grossly contaminated. The Sacramento Union in referring to the problem stated; "Redding Declares Water Polluted". The Redding City Council prepared a written protest asserting that "residents and inhabitants of (Dunsmuir, Kennett, Shasta Springs, and Shasta Retreat) . . . are depositing sewage, garbage, filth, offal, and other poisonous matters into the waters of the Sacramento River". In January 1916, nine cases of typhoid in Redding were investigated by Dr. T. J. Cummings, Director of the Bureau of Communicable Diseases. He reported that the probable source of the disease was the water supply

(at that time raw Sacramento River water) and advised that the water should be boiled before being consumed. The bacteriological quality of the northern end of the river was improved with the gradual adoption of sewage treatment by the northern communities and the construction of Shasta Dam in 1943. Beginning in 1951, bacteriological analyses became available at six stations established in the statewide stream sampling program.

Results of analyses from a station at Keswick Dam demonstrated that the quality of water in this area was good. The coliform MPN values of samples generally were below 100/100 ml. A station three miles below the Redding discharge showed high MPN values. These usually ranged between 18,000 and 36,000/100 ml. Stations at Hamilton City, Knights Landing, and Sacramento usually had a mean MPN value of from 2300 to 6200/100 ml.

In the lower reach of the river, the City of Sacramento experienced problems with contaminated water are recorded as far back as the late 1800's. The typhoid death rate averaged 53-1/2 per 100,000 annually for each five-year period from 1900 to 1915. In contrast, the average for California during the same three 5-year periods was 22.1 per 100,000. In the early 1900's, the water intake was located only 11 city blocks above one of the city's sewage discharges and during low river flows and high tides, sewage backed up to the water intake. An emergency schedule for pumping sewage to the river was set to reduce contamination to the water supply during these low flow periods. In addition, upstream raw sewage discharges to the Sacramento and American Rivers were threats to the public health. Below Sacramento, typhoid cases in labor camps were traced to the use of river water for drinking.

Water samples for bacteriological analyses were collected from the river below Sacramento as far back as 1913. From 1913 to 1931 the level of coliform bacteria downstream from Sacramento remained almost

unchanged. The average coliform MPN was 2,500/100 ml and the major portion of samples ranged between 250 and 6,200/100 ml. From 1932 and 1948 no samples were collected from the river on a routine basis.

In 1948, routine sampling was again undertaken. The results of four sampling runs in that year showed higher levels of coliform bacteria than ever recorded before. Also, it was noted that significant variations in coliform densities occurred over a short period of time. All samples collected from Sacramento to 20 miles downstream showed a MPN of 7,000/100 ml in mid-August. Two weeks later 10 of 11 samples in the same area had MPN values of 700,000/100 ml. The increase in the coliform bacteria level was attributed to peak cannery and rice field discharges in conjunction with the low September river flow.

In 1949-1954, river samples taken below Sacramento generally ranged from 10,000 to 70,000/100 ml during the spring and early summer months and from 70,000 to 700,000/100 ml in the late summer and fall.

In January 1955, the primary sewage treatment plant at Sacramento was put into operation and in July 1955, West Sacramento sewage was given primary treatment. The coliform level in the river downstream dropped to 6,000 in the summer and 20,000 - 60,000 in the fall. In 1956, the bacterial quality of the Sacramento River continued to improve. The median coliform MPN value in the spring and early summer was 2,300/100 ml and, except for one period in September when values were consistently >100,000/100 ml, the late summer MPN values were between 1,800 and 23,000/100 ml.

Coliform and Fecal Coliform Bacteria in the River

Statistical Procedures

Statisticians acquainted with the problems and limitations of bacteriological data were consulted early in the study for advice on the

techniques of evaluation most suitable for the large amount of bacteriological data collected. Reports on other major rivers throughout the country were reviewed and their approaches were considered. Other literature on the subject was examined for discussions of the advantages and disadvantages of the various methods of evaluation.

<u>Arithmetic Average</u>. The arithmetic average, usually a monthly average, has been the most often used approach in the other river studies. The fact that most bacteriological standards are based on an arithmetic average and that the average is readily understood and easily computed undoubtedly have had much to do with its popularity. One drawback to the arithmetic average is that it is very sensitive to the occasional extremely high values that may occur. In the lower reach of the river, the arithmetic averages at several stations below Sacramento were greatly influenced by a few extremely high results. Although the effect was lessened by the 30 or so other results at each station, the average indicated a much poorer water quality than actually existed for the major portion of the time. The use of the average value produced variations in the coliform profile that were not related to effects of waste discharges but rather were caused by the sensitivity of the arithmetic average to extreme values.

<u>Median</u>. For the purposes of constructing coliform profiles, the use of the median value was found to have one significant disadvantage. The median is the center value of a series of values when they are arranged according to size. Plots of median MPN values for the Sacramento River often showed a large variation or no variation between adjacent stations where, in reality, intermediate smooth values exist.

Geometric Mean. The shortcomings of the other methods of presentation discussed previously were overcome by the use of the geometric mean. The geometric mean is obtained by finding the average of the logarithms of the bacteriological results and determining the anti-log of the average. This anti-log is the geometric mean. By using the geometric mean the effects of a few extremely high numbers in a series are lessened without being ignored and when used in presenting the bacteriological data of the survey, a coliform profile was obtained which more accurately reflected the observed sanitary conditions. The geometric mean was chosen, therefore, for the presentation of the bacterial profiles of the river.

The numerical computation of the geometric mean values would have been extremely time consuming. The values, however, can be closely approximated by a graphical method described by Velz[14]. For a complete, cogent discussion of the graphical method, this reference is recommended. No complete discussion of the principles on which the determination of the geometric mean (and the ranges described below) are based will be attempted here.

There were, of course, fluctuations in the bacteriological quality of the river water during the four-day sampling period. The greatest changes would be expected in areas below sewage effluent discharges where the effects of diurnal variations in sewage flow would be most sharply defined. With the graphical method, it is possible to obtain an indication of the degree of real change in quality that takes place in the river, eliminating the variation resulting from the test method. From the graph, ranges which will include the true geometric mean during the sampling period can be obtained for any desired degree of reliability or confidence. Perhaps the best use of the "confidence range" whether it is a 50, 80, or 90 percent range is in the comparison of its spread

from station to station. A widespread between the limits of the range indicates that there has been a significant variation in the water quality; a narrow range indicate that the water quality has been fairly stable. The 50 percent range was chosen to show the relative variation in water quality during the sampling period.

A typical determination of the geometric mean density and the 50 percent confidence range is described below:

The data were arranged in order of ascending magnitude (column 1), of Table 6. A serial number (m) was assigned to each value (column 2) and the plotting position of each serial value for the probability scale was computed (column 3). The data of columns 1 and 3 were then plotted on the log probability paper as is shown in Figure 3, and a line of best fit (distribution line) was drawn. The point at which the 50 percent line cut the distribution line is considered the geometric mean. The value obtained graphically was checked by computing the geometric mean analytically from the data in column 4. In the example, the graphical value was 4,600/100 ml and the check value was 4,680/100 ml.

The 50 percent range was obtained by projecting a line parallel to the standard slope (the slope that would occur if there was no change in water quality) from the intersection of 25 and 75 percent and the distribution line to the 50 percent line. The points at which these lines crossed the 50 percent line gave the upper and lower limit of the geometric mean for the 50 percent range.

Table 6

DETERMINATION OF GEOMETRIC MEAN COLIFORM DENSITY
RIVER MILE 283.0, JUNE 6 - 10, 1960

Coliform MPN/100 ml (In order of Magnitude) (1)	Serial Number (m) (2)	Plotting Position (m/(n+1)as %) (3)	Check log of MPN/100 ml (4)
1300	1	3.1	3.114
1300	2	6.3	3.114
1300	3	9.2	3.114
1700	4	12.4	3.230
2200	5	15.5	3.342
2300	6	18.6	3.362
2300	7	21.8	3.362
3300	8	25.0	3.519
3300	9	28.1	3.519
3300	10	31.2	3.519
3300	11	34.4	3.519
4600	12	37.5	3.663
4900	13	40.6	3.690
4900	14	43.8	3.690
4900	15	46.9	3.690
4900	16	50.0	3.690
4900	17	53.1	3.690
4900	18	56.3	3.690
4900	19	59.2	3.690
7000	20	62.4	3.845
7000	21	65.5	3.845
7000	22	68.6	3.845
7900	23	71.8	3.898
7900	24	75.0	3.898
7900	25	78.1	3.898
7900	26	81.2	3.898
7900	27	84.4	3.898
11000	28	87.5	4.041
13000	29	90.6	4.114
14000	30	93.8	4.164
17000	31	96.6	4.230
			113.763

$113.763 \div 31 = 3.670$; $\log^{-1} 3.670 = 4{,}680$ = Geometric mean

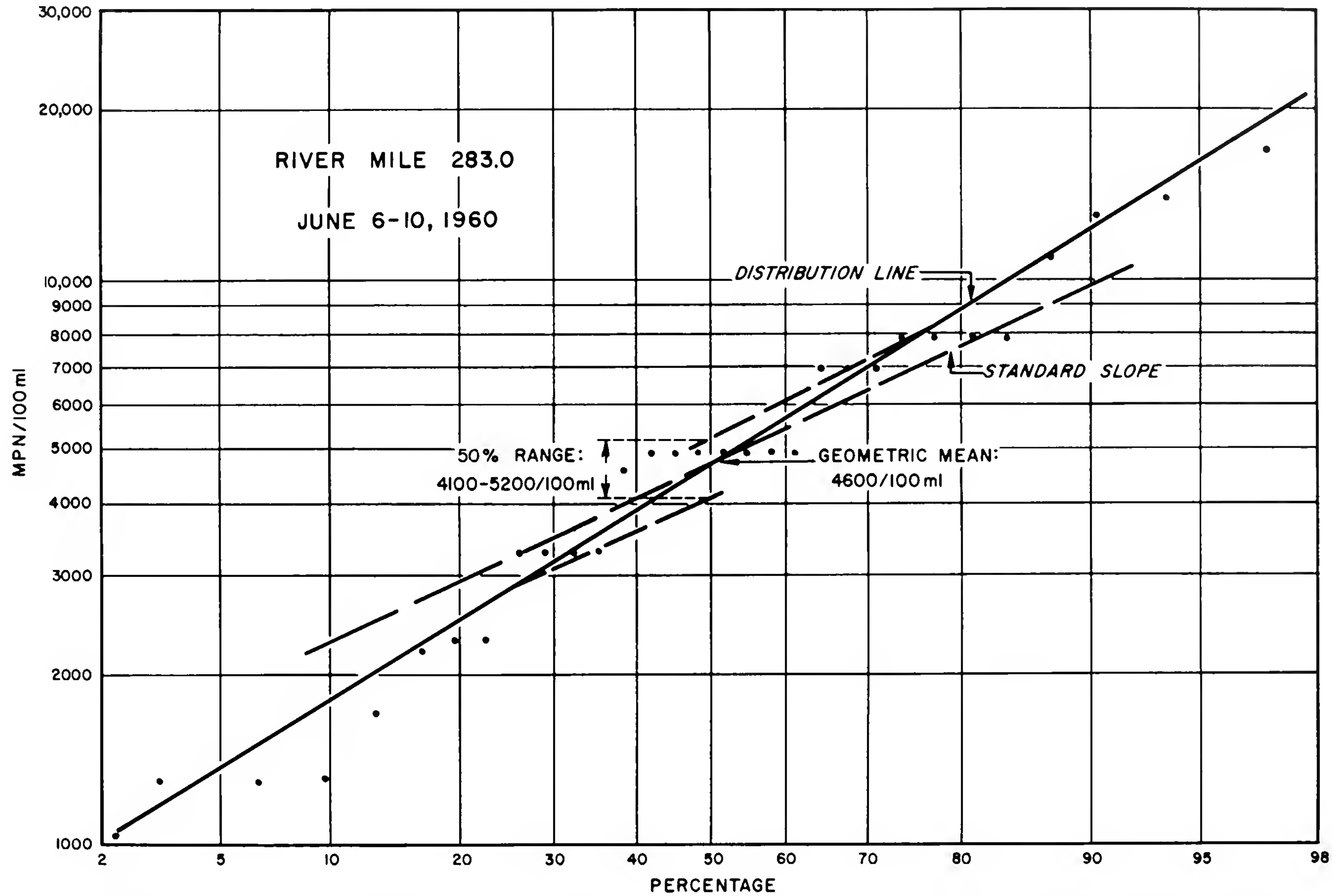


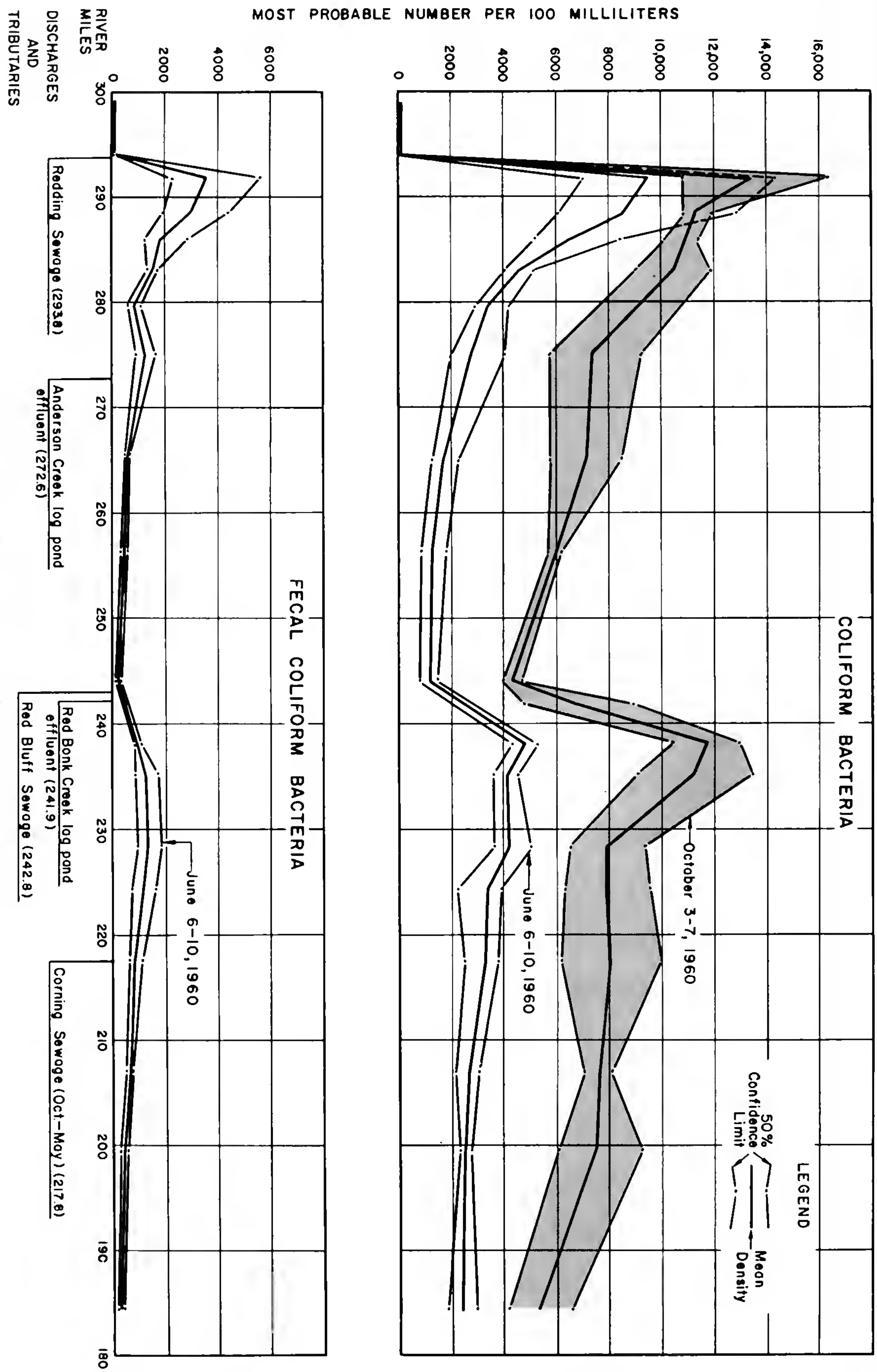
Figure 3. DETERMINATION OF GEOMETRIC MEAN COLIFORM DENSITY AND CONFIDENCE LIMITS

Upper Reach

Coliform and fecal coliform bacterial profiles for the upper reach of the river are shown in Figure 4. Basic data are listed in Table T-1 at the end of this appendix. It should be noted that the analysis for fecal coliform was performed only during the June sampling program.

An inspection of the coliform profiles reveals a difference in the levels during the two sampling periods. The amounts of sewage effluent discharged to the river by Redding and Red Bluff did not change significantly from June to October so that the higher bacterial density in the river during October is probably the result of the decreased amount of dilution water available. The river flow for the June and October periods was 8,500 cfs and 6,000 cfs, respectively. Although the amount of dilution was reduced by approximately 30 percent the bacterial density generally increased by 100 percent. For both sampling periods, there is a sharp, well-defined peak in the coliform concentration downstream from the Redding sewage treatment plant's outfall; however, below Red Bluff's effluent discharge the peak in the coliform profile is blunt and extends over a longer downstream stretch of the river. Log pond water and seepage from a pulp plant industrial pond enters the Sacramento River one mile downstream from the Red Bluff discharge. The five-day BOD of the industrial discharges generally ranged from 30 to 40 milligrams per liter in the samples collected during the survey and the flow was estimated at 1.5 mgd. This waste water may have an influence in sustaining the bacterial life over a longer period by supplying an additional source of nutrient. This assumption can not be proven with the data available and further work would have to be done to substantiate it.

In the October period, chlorinated sewage effluent from the Corning sewage treatment plant entered the river at river mile 217.5.



Geometic Mean Density and 50% Confidence Limits

Figure 4. BACTERIA IN SACRAMENTO RIVER — UPPER REACH

During the summer months the sewage effluent is diverted by a farmer to irrigate his pastures and does not reach the river. The discharge in October appeared to have no noticeable effect on the bacteriological quality of the river.

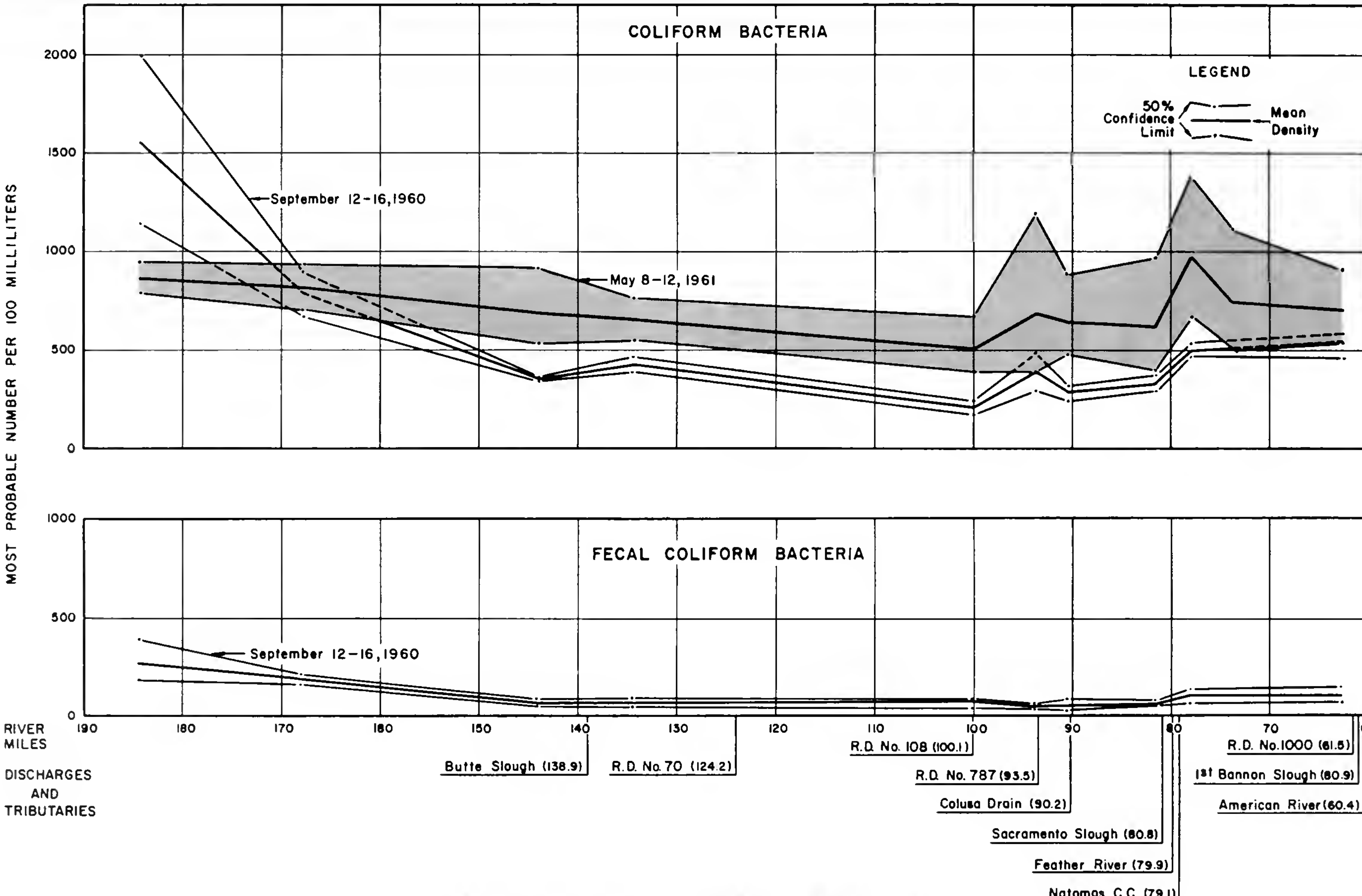
The 50 percent range indicates a greater variation in water quality during the October sampling period with the exception of the area immediately downstream from Redding.

The profile of concentrations of fecal coliform bacteria in the upper reach is similar to that for coliform bacteria. There was only one area where there was a question as to the cause of an increase in the fecal coliform density. The rise can be seen on the graph between stations 279.6 and 275. The small increase in this area occurs along a stretch of the river in which there are no sewage discharges and the only tributary of any size entering the river is Bear Creek, which drains a relatively unpopulated watershed. The reason for this increase is unknown.

The 50 percent range for the fecal coliform profile clearly indicated the wide variations in river quality downstream from the waste discharges. As the distance from the discharges increased, it appeared that the variations were dampened out and at the farther downstream station, the river quality remained fairly stable.

Middle Reach

The first sampling program for the middle reach of the river was carried out in September 1960, at the time when the rice fields were being drained. The second program was in May of the following year after the fields were first flooded. On both occasions the drains in the reach were discharging agricultural return water to the river. The bacteriological quality of the river water is shown in Figure 5. It will be



Geometic Mean Density and 50% Confidence Limits

Figure 5. BACTERIA IN SACRAMENTO RIVER—MIDDLE REACH

noted that the vertical scale for this figure has been expanded over that of Figure 4. In the September period, the residual effects of the upstream discharges can be noted at the upper end of the reach, however, these effects did not appear at the uppermost station in May. The waste water flow from Butte Slough caused an increase in the coliform level of the river during the September period but in May, perhaps because of the higher level of coliforms in the river or the lower flow from the slough, no effect was noted. Increases in coliform concentrations appeared downstream from Reclamation District 108 (R. D. 108) Drain, the Sacramento Slough - Feather River area, and the East Natomas Main Drain - American River area during both sampling periods. On the coliform profile the increases downstream from the major drains were fairly well defined, although minor. The 50 percent ranges indicated that the water quality was fairly stable in September and fluctuated more in May. It appears that the coliform level in the middle reach is increased by the agricultural drainage from above R. D. 108 to Sacramento.

From the coliform profiles of the September sampling period, it can be seen that only increases in fecal coliforms occurs below the Feather and American Rivers. The two agricultural drains, Butte Slough and R. D. 108 drain which caused an increase in the coliform density had no effect on the fecal coliform density of the river. This suggests that the fecal coliform test can be used to differentiate types of discharges. The 50 percent range indicated, as did the coliform range for the same period, that concentrations were relatively uniform.

Lower Reach

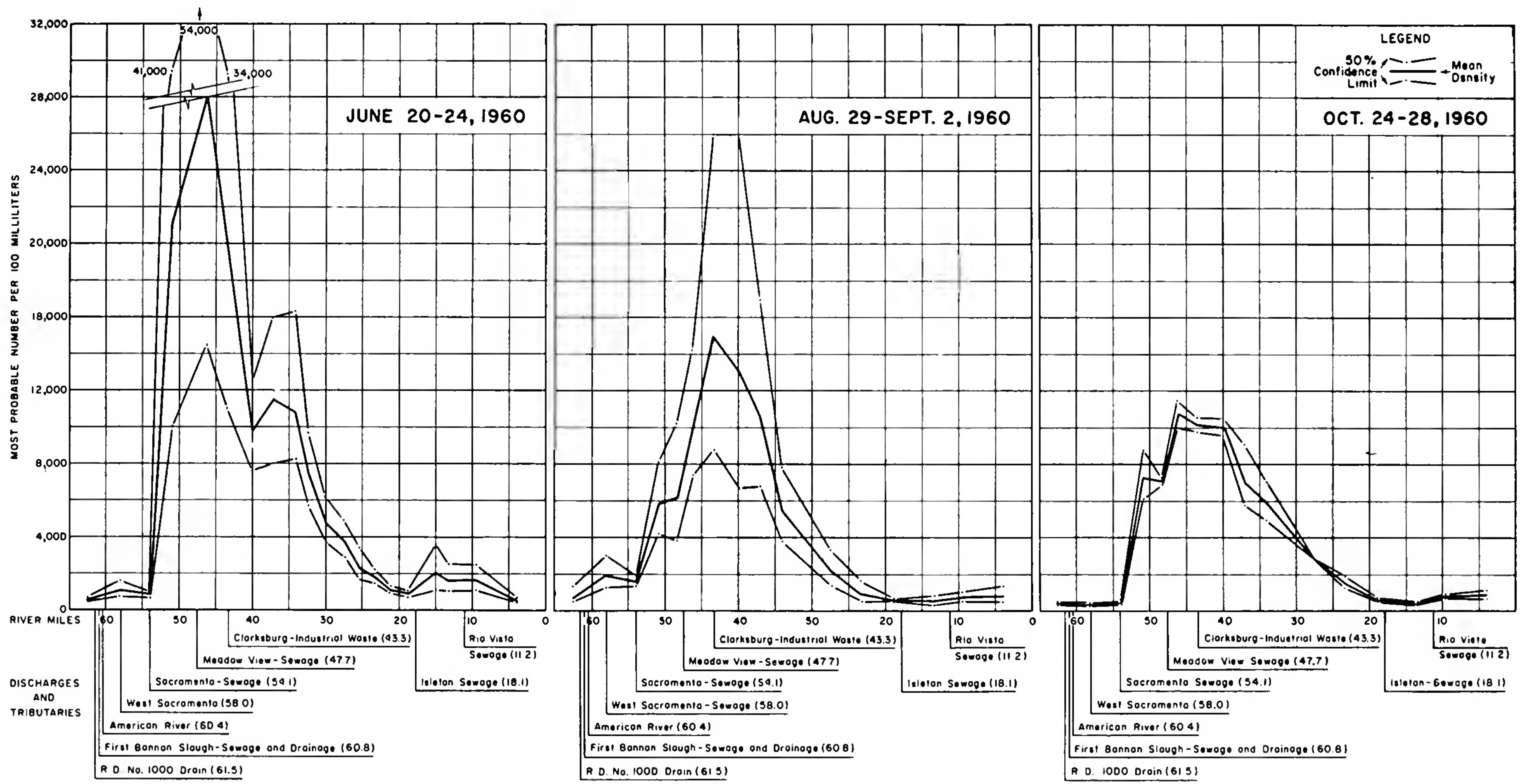
Three sampling programs were carried out in the lower reach of the river. On the first two of these programs both coliform and fecal

coliform analyses were made. It was difficult to present all the profiles on a single graph, therefore, the coliform profiles are shown on Figure 6 and the fecal coliform profiles are shown on Figure 7. During the second sampling program the final drainage of the rice fields along the middle reach of the river had begun, consequently, the coliform level immediately above Sacramento in the August 29 - September 2 period was higher than in the other periods. The effect of the American River and East Natomas Main Drain is depicted by a small rise in the coliform density below these accretions.

There are several discharges of sewage and industrial waste that enter the river within a short distance of each other in the lower reach.

West Sacramento discharges a highly chlorinated effluent at mile 58.0. No immediate effect of this discharge can be noted on the coliform profile and the next station downstream actually shows a decrease in coliform concentration. Below the Sacramento outfall (river mile 54.1) there is a rapid increase in the coliform concentration and an added increase below the Meadowview sewage discharge (river mile 47.6). This is the zone of peak concentrations of coliforms in the entire river. The Sacramento sewage treatment plant discharge, due to its far greater volume was believed to be the cause of the peak concentrations of coliform found below both plants. However, a closer inspection casts some doubt on this assumption.

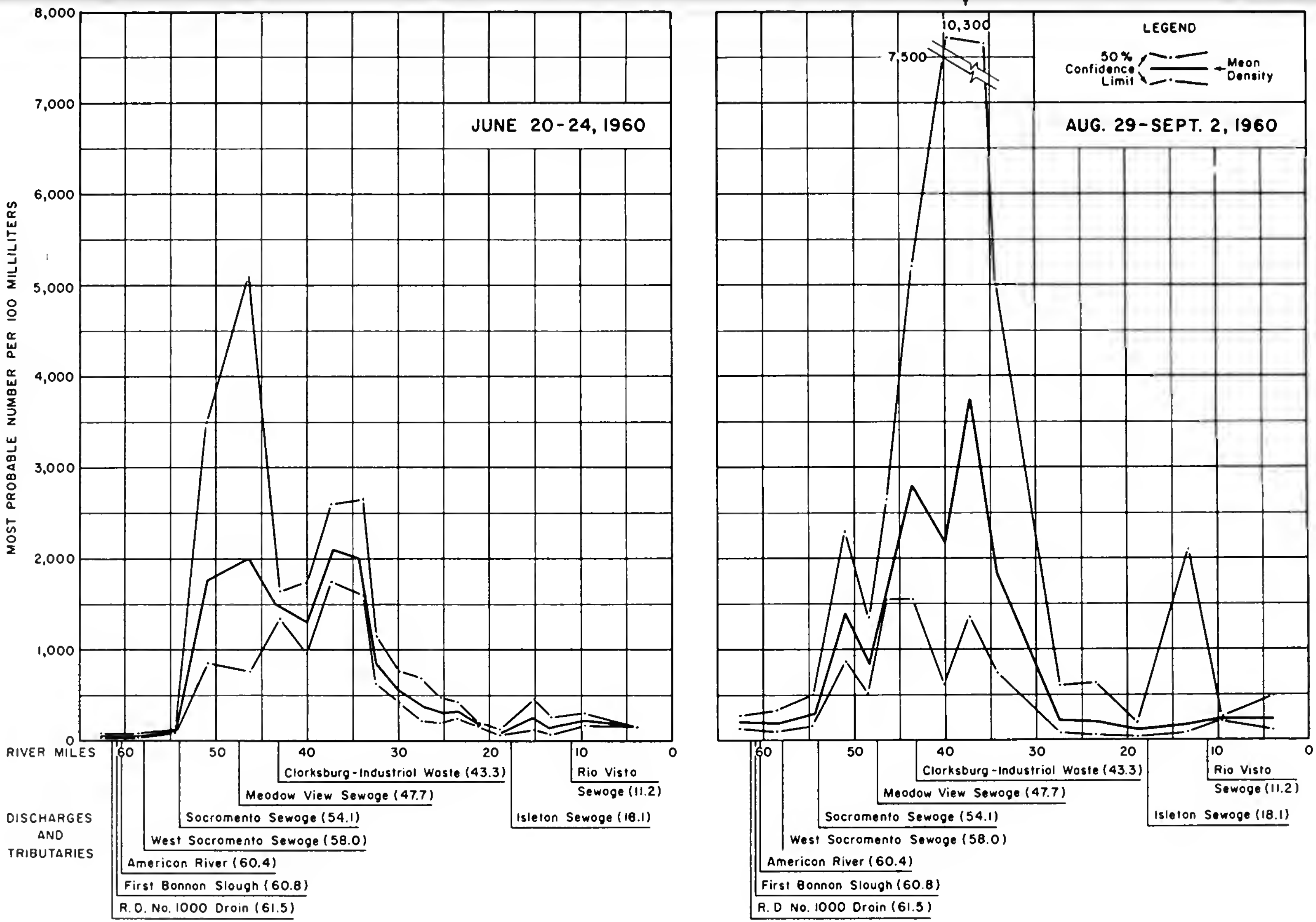
The Sacramento sewage treatment plant applies an average of 10.0 mg/L of chlorine to the plant influent for odor control and varying amounts of the effluent for disinfection. For the three sampling periods the postchlorination dosage was as follows: 1.0 - 2.0 mg/L was applied in June; 3.0 - 3.5 mg/L in the August - September period; and 4.0 mg/L in October. The effect of the incremental increase in postchlorination



Geometric Mean Density And 50% Confidence Limits

Figure 6. BACTERIA IN SACRAMENTO RIVER LOWER REACH

COLIFORM BACTERIA



Geometric Mean Density And 50% Confidence Limits

Figure 7. BACTERIA IN SACRAMENTO RIVER LOWER REACH
FECAL COLIFORM BACTERIA

dosage can be seen by the general reduction in the coliform concentration downstream. (The effect of the change in postchlorination dosage will be discussed in detail in a subsequent section.) During the June period there was only one station between the Sacramento discharge and the Meadowview discharge, therefore, there was no possibility of determining whether the results at this station depicted the peak attained by the coliform contributed by the Sacramento discharge or was merely a point on the upslope of the peak. On the second and third sampling runs an additional station was established between the two discharges and the coliform bacteria showed a "leveling off" at the two stations followed by a second increase below the Meadowview treatment plant. This level area would tend to indicate that the coliform bacteria contributed by the Sacramento discharge caused a density of 6,000 - 8,000 coliform per 100 milliliters in the river during the August - September and October periods. The Meadowview discharge then caused the second increment of rise and resulted in the peak of 10,000 to 15,000 coliform bacteria per 100 milliliters. The flow at the Meadowview plant is small (0.25 mgd), roughly 1/200 of the flow of the Sacramento plant; however, the effluent is not disinfected and contains more than 200 times the number of organisms per unit volume than that of the Sacramento discharge. Thus, in spite of the great difference in flows, the total number of organisms added to the river by the two discharges is roughly equal.

The sugar beet processing plant at Clarksburg (river mile 43.3) discharged process water to the river during the August - September and October sampling periods. Its effect on the coliform level of the river appears to be minor in comparison with the effect of the Sacramento and Meadowview discharges.

A secondary peak can be seen on the June profile in the area of river mile 35. This peak occurs in an area of the river where there are no waste discharges entering the river. The cause of this rise in the coliform level was not found.

The Isleton discharge at river mile 17.8 increased the coliform level during the June sampling period. For several days during that period the plant chlorination equipment was not in operation. During the other sampling periods when the sewage effluent was chlorinated, no change in the coliform density was observed. The Rio Vista sewage discharge produced no noticeable effect, although a local effect might have been missed, since the river in that area is wide and samples were collected at mid-stream while the sewage discharge is near the right bank.

The 50 percent ranges of the coliform bacteria showed that great variations in coliform density occurred during the June sampling period below the Sacramento and Meadowview discharges. The variations were decreased in the August - September period and in October remarkably stable conditions were found.

Fecal coliform analyses were performed during the June and August - September periods. The geometric mean profiles show increases below the Sacramento and Meadowview plants. Although the sugar beet plant at Clarksburg was discharging process water during the August - September period, there was a definite decrease in the fecal coliform level at the first station downstream. A similar decrease can be seen in the June period when the plant was not in operation. This would indicate that the plant discharge does not have an effect on the fecal coliform content of the river. The unexplained peak in the June coliform profile at river mile 35 also was revealed in both fecal coliform profiles. At the lower end of the reach the Isleton and Rio Vista sewage effluent discharges

caused minor increases in the fecal coliform level. The 50 percent range indicated that there were much greater fluctuations in the fecal coliform concentrations during the August - September sampling period than in the June period.

Disappearance Rates of Coliform and Fecal Coliform Bacteria

Receiving waters are generally an unfavorable environment for bacteria of intestinal origin. When the environment is completely unfavorable to their existence, the bacteria may also immediately begin a die-away phase at a rate that, like the decay of a radioactive material, can be expressed by a unimolecular equation. Chick [15], in her studies on the effect of disinfectants on B. paratyphosa, proposed a formula for the logarithmic die-away rate that can be expressed; $\frac{Nt}{No} = 10^{-Kt}$

Where, No = survivors after time t.
Nt = initial population at t = 0
K = rate of constant

$$\text{and } K = \frac{\text{Log } Nt/No}{t}$$

Chick and others observed that after extended exposure, the death rate (K) gradually diminished. This was believed to be due to the higher resistance of hardier cells among the surviving bacteria. Studies of the pollution and self-purification of several rivers in the mid-west provided more information regarding the rate of die-off of bacteria [16,17]. In each study it was noted that after a prolonged travel time in the river below a waste discharge, the rate of die-off gradually diminished. Again, the change in rate was believed to be due to the disappearance of the less resistant strains of bacteria and to the predominance of more resistance types. In order to allow for this situation, Streeter [18] developed a formula for a mixed bacterial population; (expressed in the same terms) $\frac{Nt}{No} = \frac{1-10^{-K't}}{2.3\ K't}$ which allowed for a decreasing die-away rate.

These other river studies also indicate that there was a time interval downstream from the waste discharges during which the bacterial density increased. The period from the point of discharge to the point of peak density is generally referred to as the lag period. The disintegration of sewage particles and subsequent exposure of additional bacteria, the growth of bacteria which had been inhibited previously by chlorination, and the more rapid initial multiplication of bacteria over the predators are some explanations that have been proposed for the lag period.

The logarithmic die-away portion of the curve may be expressed with Chick's formula by allowing for the lag period. Then,

$$\frac{Nt}{No} = 10^{-K\,(t_2 - t_1)}$$

where t_1 = lag period in days.

t_2 = time in days from t_1.

There are three major discharges on the Sacramento River that lend themselves to an evaluation of disappearance rates. These are the sewage discharge from the communities of Redding and Red Bluff and the combination of discharges in the Sacramento area which enter the river within a few miles of each other. The travel times from the discharges to the downstream river stations used in the bacteriological sampling program were determined. The mean density of the bacterial population at the first point below the discharge was given the value of 100 percent and the percentage of coliform at the downstream stations were computed on this base. The disappearance rates were plotted on semi-log paper. (Figures 8 and 9.) The plots are more accurately described as disappearance curves rather than die-away curves since the bacteria are also subject to removal by sedimentation of sewage particles.

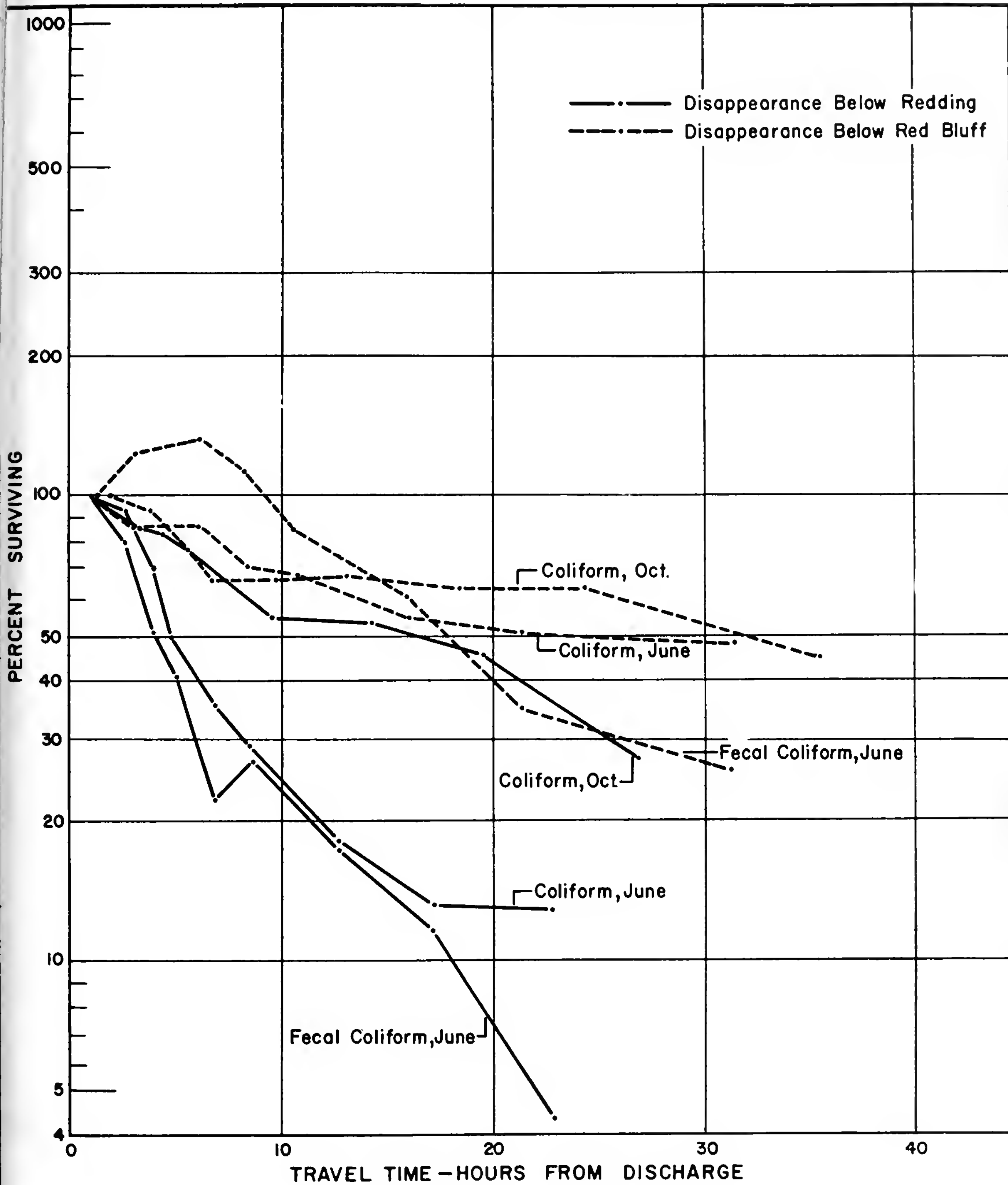


Figure 8. DISAPPEARANCE OF COLIFORM AND FECAL COLIFORM BACTERIA DOWNSTREAM FROM REDDING AND RED BLUFF

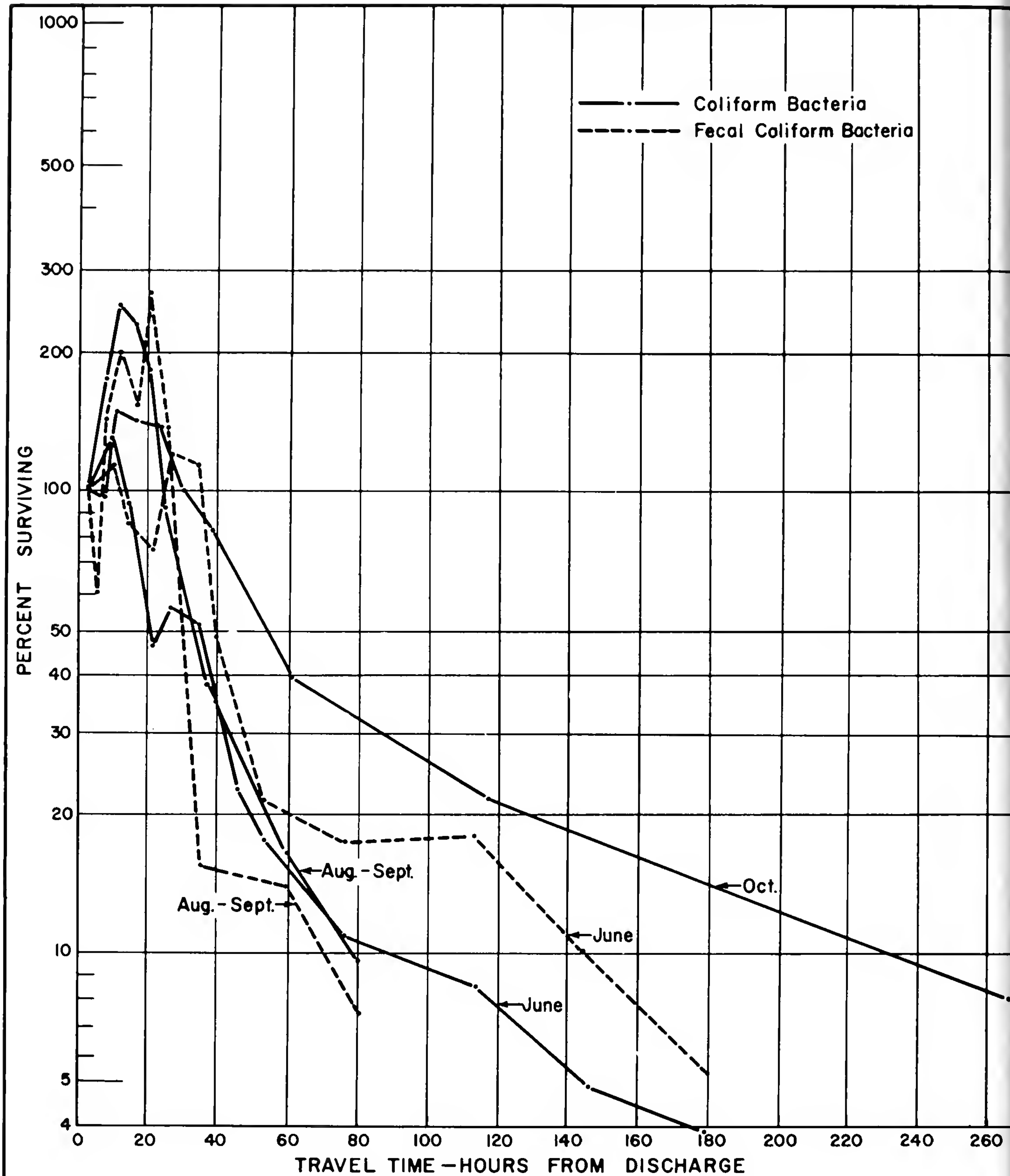


Figure 9. DISAPPEARANCE OF COLIFORM AND FECAL COLIFORM BACTERIA DOWNSTREAM FROM SACRAMENTO

Redding

The Redding sewage treatment plant discharges an unchlorinated primary domestic effluent into the Sacramento River. Here the river is clear, cold, and low in organic and mineral constituents. On the June and October sampling programs, 76 and 94 percent, respectively, of the coliform bacteria discharged in the effluent appeared at the first station downstream, which was the peak point in the disappearance curve, approximately two miles or 1.2 hours below the discharge. From that point moving downstream for a travel time of 22 - 27 hours, there was an almost straight line logarithmic drop-off of the percent coliform and fecal coliform in the river. The results would indicate that the river is a decided foreign environment to the bacteria in this area and that because of the influence of various factors such as sedimentation, competitive life and unfavorable temperatures, the bacteria cannot survive in this water. The immediate drop-off in bacterial density observed at Redding differed from results found in previous studies of the Ohio, Illinois, and Upper Mississippi Rivers [17,19,20] where it was indicated that the peak coliform density may be expected after a travel time of 10 - 24 hours below the source of pollution. These previous studies dealt, for the most part, with raw sewage discharges containing large particles of fecal matter that would gradually disintegrate in the river. At Redding, the primary treatment had removed the larger particles and consequently, there was less exposure of additional bacteria by the breakdown of sewage particles. This may account for the lack of a lag period.

Red Bluff

The wastes treated at the Red Bluff primary sewage treatment plant are domestic sewage from the community and waste water from a

slaughter house and tallow works in town. The tallow works and slaughter house wastes are discharged during the night when there are low flows. The water temperature, velocity of flow, turbidity, and general mineral quality of the river below Red Bluff are similar to the area below Redding. There is a waste water discharge of approximately 1.5 mgd from a pulp and paper mill that enters the river downstream from the Redding discharge. The major portion of flow from the pulp mill is log pond water and the rest is process water which percolates through the banks of holding ponds.

In the June sampling program only 46 percent of the coliform bacteria in the Red Bluff discharge was found at the first station, 3.7 miles (two hours) downstream. The coliform bacteria in the river then disappeared at a fairly regular logarithmic rate. The fecal coliform bacteria had a nine-hour lag period before entering the die-away phase. Since, in comparison to Redding, a small percent of the coliform bacteria introduced by the Red Bluff sewage discharge appeared at the first downstream station, it was felt that the peak concentration may have occurred closer to the discharge and that the first station was actually on the downslope of the coliform profile. For the October program an additional station was established only a half-hour below the discharge. There was some doubt that results from this station would be a valid representation of conditions in the river, since it was so close to the sewage outfall that complete mixing may not have occurred. The bacteriological results of the October sampling program indicated that there was an increase in coliform below the new station and that the peak was in the area of the station 3.7 miles below the discharge. This time 100 percent of the coliform in the waste discharge was found at the peak. In view of the uncertainty of the results obtained at the new station and in order to better compare the disappearance curve for two periods, the station 3.7

miles below the outfall was taken as the 100 percent value for both disappearance curves. It appears that the lag period for the coliform bacteria below Red Bluff, if indeed there is one, extends for less than two hours. The reason for the low percent of coliform in the June sampling period at the first downstream station was not resolved.

Sacramento

The river near Sacramento receives the effluents of many small secondary treatment plants serving outlying areas and the heavily chlorinated sewage effluent from the West Sacramento primary treatment plant. The Sacramento primary sewage treatment plant discharges 40 - 65 mgd of chlorinated effluent at river mile 54.1. A small flow of unchlorinated primary effluent (0.25 mgd) enters the river several miles below the Sacramento discharge from the Meadowview sewage treatment plant, and approximately 10 miles below the Sacramento outfall a significant amount (4 mgd) of sugar beet waste water enters the river from August to December. The coliform peak occurs below the Meadowview discharge and appears to be the result of the combined effect of the Sacramento and Meadowview discharges.

The peak of the coliform curve occurred several hours downstream from the Meadowview discharge, however, the peak point on the fecal coliform curves appeared approximately 11 hours further downstream. Thus, the fecal coliform disappearance curves were the only disappearance curves that exhibited a definite lag period. After reaching the point of peak population, the disappearance of coliform and fecal coliform bacteria in all cases proceeded at a remarkably similar rate. During the survey program, subresidual postchlorination dosage at the Sacramento sewage treatment plant was gradually increased from the first to the third

sampling runs. It appeared that increased postchlorination had some ill-defined effect in extending the lag period of the fecal coliform. It also had the effect, not shown on these graphs, of reducing the concentration of coliform organisms in the river, however, it apparently had no effect on the disappearance rate when the peak population was achieved.

During two sampling periods, the travel time downstream from the peak coliform population was sufficiently long for a decrease in the disappearance rate to appear. Approximately 60 - 80 hours below the peak there is a change in the slope of the disappearance curve.

<u>Comparison of Average Disappearance Rates</u>

Because of the constant logarithmic disappearance of the coliform and fecal coliform bacteria for most of the disappearance curves, it was felt that Chick's equation, modified for the lag period where necessary, could be used to express the disappearance of the bacteria, and the death rate constant (K) could be found from $K = \frac{\log N_1/N_2}{t}$. In the case of Sacramento, the initial disappearance rate for the first 60 - 80 hours below the peak was computed. The average K values of the disappearance curves were determined by the method of least squares and are tabulated in Table 7.

The rate of disappearance of the fecal coliform was generally greater than for the coliform group. In the upper reach, the K values for coliform bacteria were smaller during the October period than in June; the Red Bluff values were considerably smaller than those for Redding. Factors that might influence disappearance rates were investigated to see if there was a relationship that could account for the difference in K values at Redding and Red Bluff. These are shown in Table 8.

Table 7

AVERAGE "K" VALUES FOR COLIFORM DISAPPEARANCE

$$K = \text{LOG}\ \frac{N_1/N_2}{t}$$

Redding			Red Bluff			Sacramento		
	Coliform	Fecal Coliform		Coliform	Fecal Coliform		Coliform	Fecal Coliform
6/6-10/60	1.095	1.352	6/6-10/60	0.232	0.695	6/20-24/60	0.442*	0.436*
10/3-7/60	0.415		10/3-7/60	0.190		8/29-9/2/60	0.529	0.564
						10/24-28/60	0.305*	

* Initial disappearance rate.

Table 8

FACTORS POSSIBLY INFLUENCING COLIFORM BACTERIA DISAPPEARANCE RATES REDDING AND RED BLUFF

	Redding		Red Bluff	
	June	October	June	October
"K" Value	1.10	0.42	0.23	0.19
Velocity (ft./sec.)	2.8	3.3	2.4	2.9
Temperature (°F)	51.	54.5	59.	59.
5-Day BOD Below Discharge (mg/L)	0.85	0.79	0.66	0.75
Turbidity (Turbidity Units)	5 - 6	2 - 4	5 - 6	3 - 4

There does not appear to be a difference in the factors investigated that might account for the difference in K values.

In Figure 10 the average disappearance curves downstream from the Redding, Red Bluff, and Sacramento discharges have been compared with the disappearance curves in the Illinois River below Chicago and Peoria [20] and the Mississippi River below Minneapolis - St. Paul [17]. In these other rivers the bacterial densities were followed for much longer travel times than were available in the Sacramento River. The disappearance curves shown are the lines of best fit for the bacterial concentrations in the rivers under summer conditions.

It can be seen that the disappearance of coliform organisms in the Sacramento River from the point of peak population proceeded more slowly than in the other rivers, with the exception of the June period below Redding. The Sacramento River is a "clean stream" in comparison to these other rivers. The differences in disappearance rates supports observations by others that more polluted streams will have a higher initial die-away rate.

Effect of Increased Postchlorination at Sacramento Sewage Treatment Plant

In order to evaluate the effects of chlorination at the Sacramento sewage treatment plant on the bacterial quality of the river downstream from the discharge, it is necessary to describe the rather involved chlorination practice that is carried out. Raw sewage contributed by several sanitation districts to the Sacramento sewerage system is chlorinated at each district's pumping station for sulfide control. The treatment plant is surrounded by costly modern homes whose proximity requires a close control of odors. For odor control an annual average of 9.3 milligrams per liter (mg/L) of chlorine is added to the raw sewage at the plant

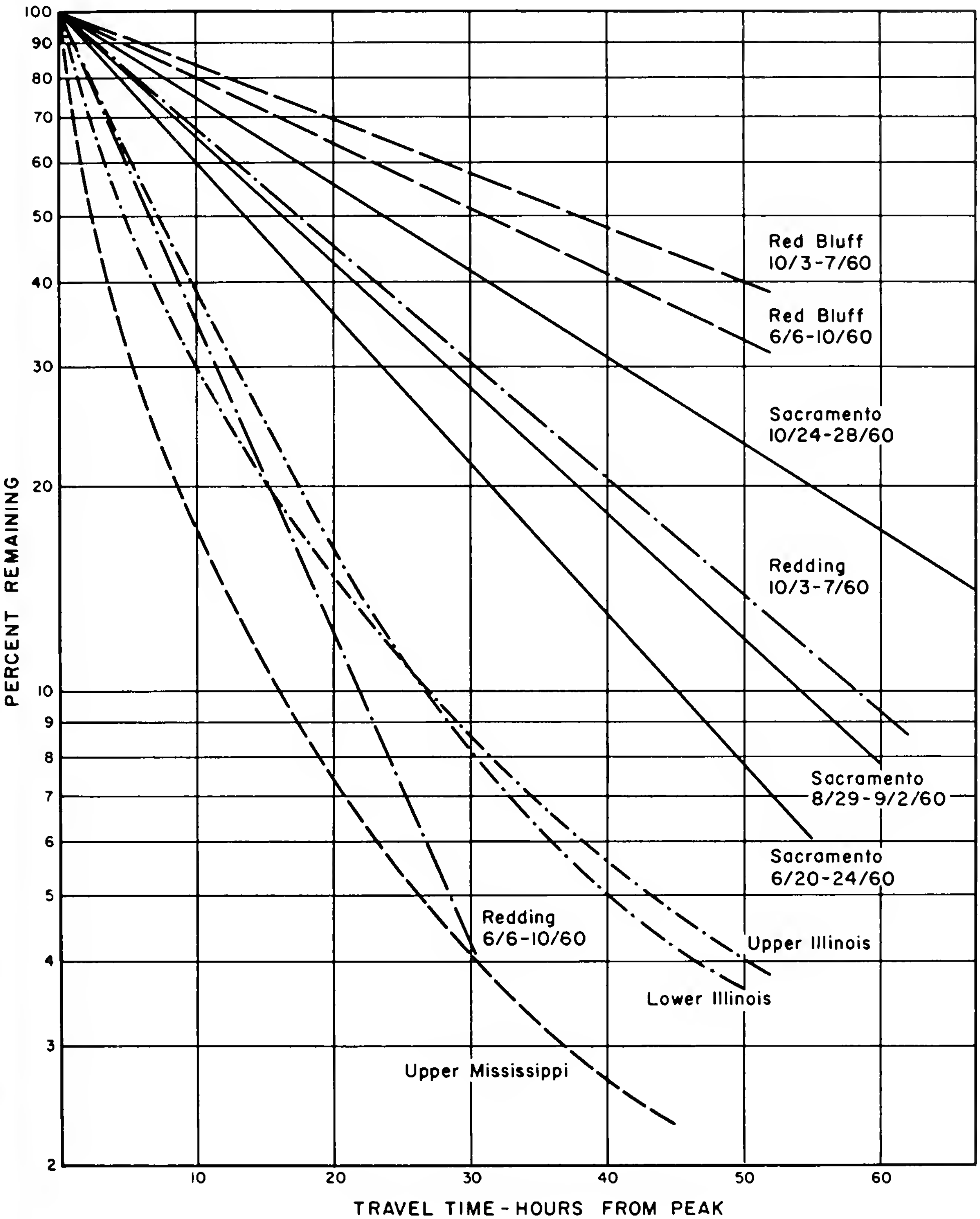


Figure 10. COMPARISON OF DISAPPEARANCE RATES OF COLIFORM BACTERIA IN THE SACRAMENTO RIVER WITH OTHER RIVERS

headworks. The dosage is dependent upon the amount needed to control odors so that, during the winter months, when the sewage is diluted with storm water, the average dosage of chlorine may be from 7 to 8 mg/L and during the heavy canning season in August and September, the dosage may rise to 11 mg/L. Postchlorination is practiced during the recreational season. This is designated as the period when the air temperature in the area reaches or exceeds 80 degrees Fahrenheit. The postchlorination dosage rate is governed by the results of bacteriological samples taken at downstream stations. If the results of such samples are extremely high, the chlorination dosage is increased until the coliform values drop. Normally postchlorination is practiced from May until mid-October. During the 1960 recreational season, the following postchlorination schedule was carried out:

May 27; postchlorination commenced - 2.0 mg/L
June 9; 12 noon; chlorination reduced - 1.0 mg/L
June 22; 3 p.m.; chlorination increased - 2.0 mg/L
August 18; chlorination increased - 2.5 mg/L
August 26; chlorination increased - 3.0 mg/L
August 31; noon; chlorination increased - 3.5 mg/L
September 14; chlorination increased - 4.0 mg/L

Although the changes in chlorination were made completely independent of the river survey, they gave an opportunity to evaluate the effects of various postchlorination dosages on the bacteriological quality downstream from the discharge. On June 22, 1960, during the first sampling period, the postchlorination dosage was increased from 1 to 2 mg/L. The travel times from the point of discharge to the downstream stations were used in separating samples taken from the river when the effluent was given a 2.0 mg/L postchlorination dosage from those taken from the

river when the chlorination dosage was 1.0 mg/L. During the second sampling period from August 29 to September 2, the postchlorination dosage was 3.0 to 3.5 mg/L. During the last sampling period from October 24 to 27, the chlorination dosage was maintained at 4.0 mg/L. The median MPN values for the downstream stations are plotted in Figure 11.

There are other discharges which influence the bacteriological quality in the river below the City of Sacramento. The West Sacramento and the Meadowview sewage treatment plants discharge effluent near Sacramento, and the American Crystal Sugar Company at Clarksburg discharges sugar beet processing water from August to December. Despite the inability to determine the separate effects of each discharge, there still was a decided decrease in the coliform content of the river below the Sacramento outfall when the postchlorination dosage of Sacramento was increased to 2.0 mg/L or higher. The results indicate that increased chlorination significantly decreases the coliform content below the Sacramento outfall, however, the effects of still higher postchlorination dosages will have to await future investigation.

Coliform and Fecal Coliform Bacteria in Waste Discharges

The coliform and fecal coliform content of all waste discharges, drains, and major tributaries to the river are summarized in Table 9. It can be seen from the table that the sewage treatment plants discharging unchlorinated sewage to the river, although variable from discharge to discharge, showed consistent results for each discharge during the different sampling periods. The agricultural drains located in the middle reach of the river consistently showed relatively low numbers of coliform organisms. The West Sacramento sewage treatment plant provides a chlorination dosage resulting in a residual of 0.5 to 1.0 ppm free

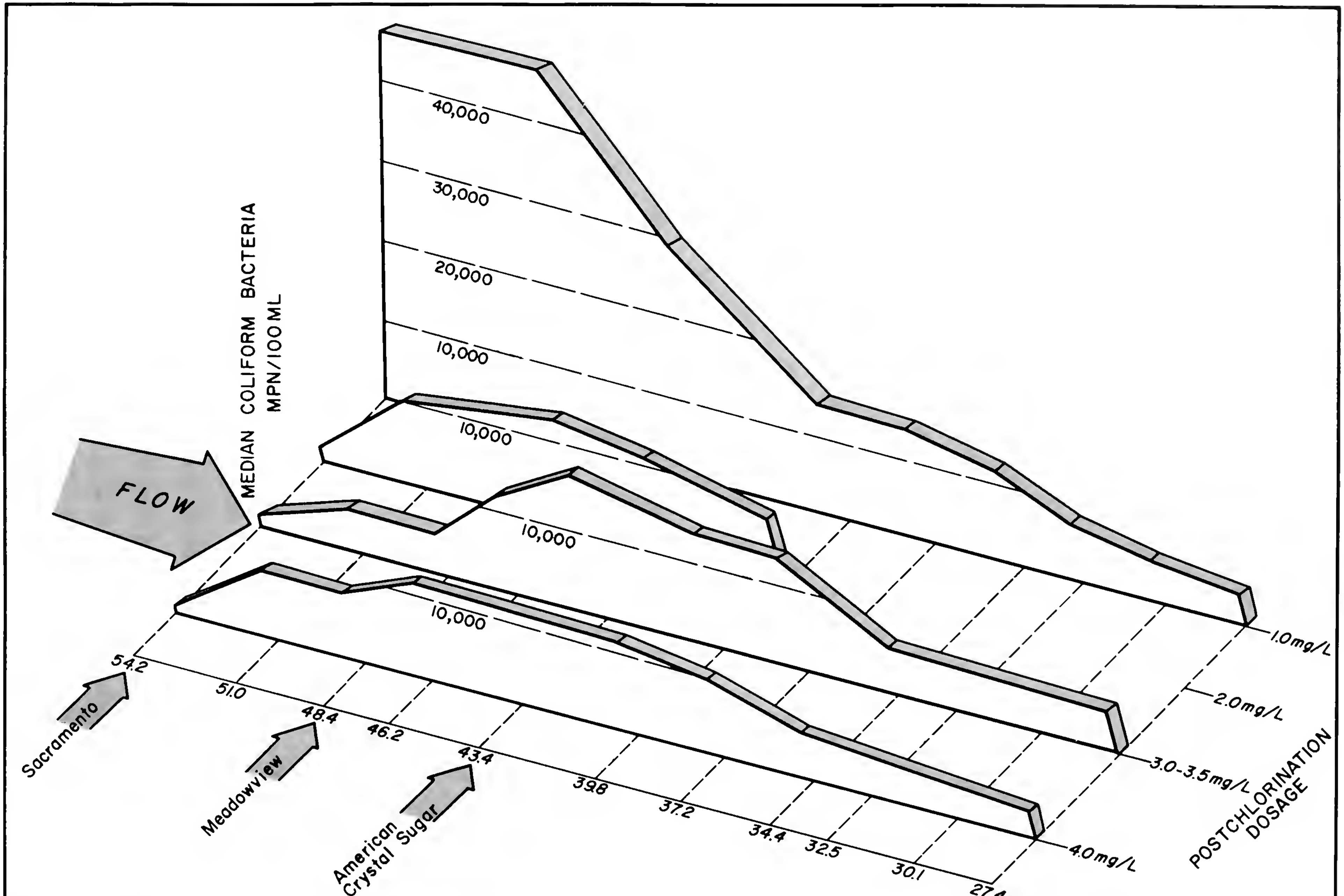


Figure 11. RELATIONSHIP OF RIVER COLIFORM DENSITY AND SACRAMENTO SEWAGE TREATMENT PLANT POSTCHLORINATION DOSAGE

Table 9

COLIFORM AND FECAL COLIFORM BACTERIA,
WASTE DISCHARGES, DRAINS AND TRIBUTARIES

Discharge	Date	Type of Waste	River Mile	Coliform Bacteria MPN/100 ml No. of Samples	Coliform Bacteria MPN/100 ml Mean Density	Fecal Coliform Bacteria, MPN/100 ml No. of Samples	Fecal Coliform Bacteria, MPN/100 ml Mean Density	Fecal/Total (percent)	Remarks
			Upper Reach						
Redding sewage treatment plant effluent	6/6-6/10/60	Domestic sewage, primary treatment	293.8	29	38,200,000	18	10,800,000	22.9	To determine the fecal/ total coliform, the arithmetic averages of the samples analyzed for both types were used.
	10/3-7/60		293.8	31	39,000,000	--	---	----	
Log pond		Log pond water	290 ±	21	2,200	21	180	10.3	
Red Bluff sewage treatment plant effluent	6/6-10/60	Domestic sewage primary treatment	242.8	32	30,400,000	17	13,300,000	39.0	
	10/3-7/60		242.8	32	29,000,000	--	---	----	
			Middle Reach						
Butte Slough	9/12-16/60	Agricultural drainage	138.9	32	1,530	15	110	7.8	
	5/8-12/61			24	1,350	--	---	---	
Reclamation District No. 70	9/12-16/60	Agricultural drainage	124.2	26	2,510	13	300	9.3	
	5/8-12-60			24	1,750	--	---	---	
Reclamation District No. 108	8/30-9/2/60	Agricultural drainage	100.1	23					Preliminary sampling.
	9/12-16/60			32	2,420	16	200	12.6	
	5/8-12/61			24	2,900	--	---	----	
Reclamation District No. 787	9/12-16/60	Agricultural drainage	93.6	32	1,400	17	95	8.6	
	5/8-12/61			16	4,400	--	---	---	
Colusa Basin Drain	8/30-9/2/60	Agricultural drainage	90.2	23					Preliminary sampling.
	9/12-16/60			31	1,180	13	160	12.9	
	5/8-12/61			24	2,500	--	---	----	
Sacramento Slough	8/30-9/2/60	Agricultural drainage	80.8	23					Preliminary sampling.
	9/12-16/60			32	2,170	15	260	13.2	
	5/8-12/61			24	1,950	--	---	----	
Feather River	9/12-16/60	Tributary water	80.0	32	360	17	50	16.4	
	5/8-12/61			24	590	--	---	----	
Natomas Main Canal	9/12-16/60	Agricultural drainage	61.5	32	2,730	18	330	9.6	
Reclamation District No. 1000	5/8-12/61	Agricultural drainage	66.3	10	4,600	--	---	---	
			Lower Reach						
Natomas East Main Drain	6/20-24/60	Agricultural drainage and secondary treatment plant effluents	60.9	15	55,900	6	4,500	3.0	
	8/29-9/2/60			15	9,490	5	2,850	31.5	
	10/24-28/60			16	6,250	-	---	----	

Table 9

COLIFORM AND FECAL COLIFORM BACTERIA
WASTE DISCHARGES, DRAINS AND TRIBUTARIES
(continued)

Discharge	Date	Type of Waste	River Mile	Coliform Bacteria MPN/100 ml		Fecal Coliform Bacteria, MPN/100 ml		Fecal/Total (percent)	Remarks
				No. of Samples	Mean Density	No. of Samples	Mean Density		
			Lower Reach (continued)						
American River	6/20-24/60	Tributary water	60.4	16	1,950	8	<180	*	* Indeterminate
	8/29-9/2/60			17	6,180	7	280	17.9	
	10/24-28/60			16	1,260	-	---	----	
West Sacramento sewage sewage treatment plant effluent	6/20-24/60	Domestic sewage slaughter-house wastes, primary treatment and chlorination	58.0	10	460	5	<180	*	* Indeterminate
	8/29-9/2/60			15	2,110	6	1,200	13.1	
	10/24-28/60			16	300	-	---	----	
Sacramento sewage treatment plant effluent	6/20-24/60	Domestic sewage, cannery wastes, primary treatment and chlorination	54.1	11	402,000	5	72,500	38.0	Poor sampling point.
	8/29-9/2/60			32	43,500	15	12,600*	38.0	* Many indeterminate values.
	10-24-28/60			27	124,000	--	---	----	
Meadowview sewage treatment plant effluent	6/20-24/60	Domestic sewage, primary treatment	47.7						
	8/29-9/2/60			17	22,100,000	8	14,300,000	85.0	
	10/24-28/60								
American Crystal Sugar Company plant effluent	6/20-24/60	Beet sugar wastes after one-day ponding	43.3						
	8/29-9/2/60			16	199,000	7	39,000	16.6	
	10/24-28/60			16	472,000	-	---	----	
Isleton sewage treatment plant effluent	6/20-24/60	Domestic sewage primary treatment and disinfection	17.5	4	356,000*				* Chlorination interrupted.
	8/29-9/2/60			9	620	4	80	60.5	
	10/24-28/60			16	34,800	-	---	----	
Rio Vista sewage treatment plant effluent	6/20-24/60	Domestic sewage, primary treatment	11.6	4	11,600,000				
	8/29-9/2/60			16	14,000,000	7	7,650,000	48.9	
	10/24-28/60			12	13,200,000	-	---	----	

available chlorine in the effluent after a one hour contact period. The effective chlorination resulted in a low coliform content of the effluent. During the first sampling period, the Sacramento sewage treatment plant effluent samples were collected from a sump near the point of chlorine application where little chlorine contact time was available. During the second and third sampling periods, the samples were collected from the stream of sewage effluent at the river outfall which allowed a 20 - 30 minute contact period from the point of postchlorination. There may have been some dilution of the sewage with river water at this station, however, it was the only sampling point available and it was felt that the results were more representative of the sewage quality entering the river than the results of samples taken at the plant sump. The Isleton sewage treatment plant chlorination facilities were not in operation for two days during the first sampling period because of the break in the chlorine solution feed line. This resulted in the high coliform bacteria densities of the effluent for this period.

Relative Percentage of Fecal Coliform Bacteria

In order to compare the number of fecal coliform organisms to the number of coliform organisms in the various types of discharges, the MPN values for those samples on which both analyses were performed were averaged and the percent of fecal coliform organisms of the total was computed. The results are summarized on Figure 12. There was a considerable variation in the percentages of fecal to total coliform organisms in the sewage discharges, however, the percentages were generally higher than the percentages for any other type of discharge. There appeared to be no correlation between disinfection and the proportion of fecal coliform to total coliform organisms. The sugar beet wastes from the

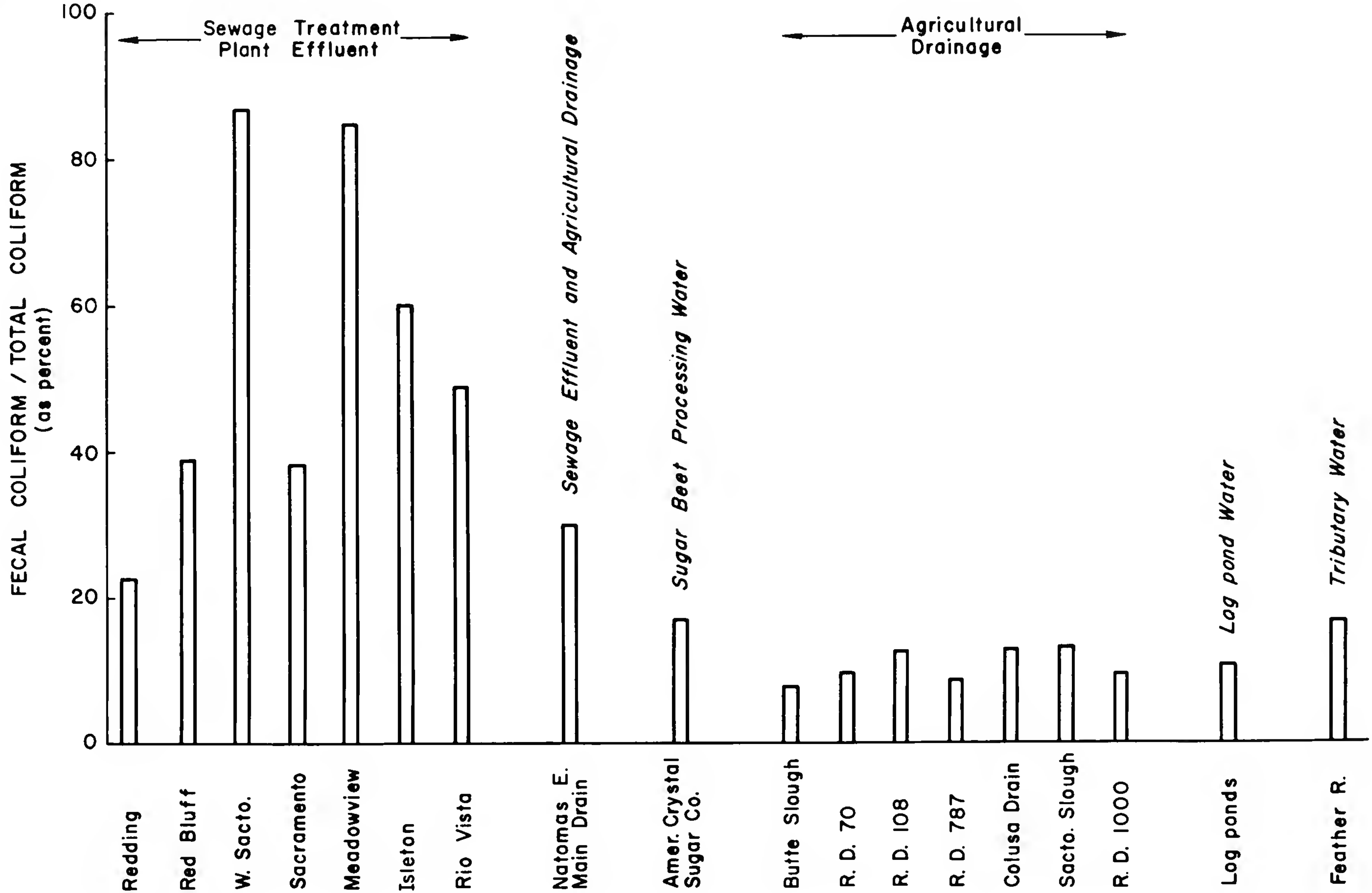


Figure 12. RATIO OF FECAL COLIFORM TO TOTAL COLIFORM DENSITIES FOR DISCHARGES, DRAINS AND TRIBUTARIES

Clarksburg plant had the next highest percentages, 16.6 percent. A small portion of the flow from this plant is sewage from the employee rest room facilities, however, this waste water is given secondary treatment and chlorination so that the percentage is probably representative of the ratio of fecal organisms to total coliform organisms in sugar beet waste. The sloughs and drains which carry agricultural return water all fall within a close percentage range from 8 to 13 percent. The log ponds contain the lowest percentage of 10.3 percent. These results indicate there is a degree of difference in the relative concentrations of fecal coliform organisms and total coliform organisms with the type of waste discharge. The agricultural drains and discharges containing little or no sewage had the lowest percentages of fecal coliform organisms and the sewage discharges had the highest percentages.

The relations between fecal and total coliform populations in the river itself are less apparent. Severe limitations in the data became apparent in analysis of ratios in the river. During the June sampling period on the lower reach, many of the fecal coliform results were indeterminate and an accurate determination of an average or median ratio was not possible. In the middle reach, where agricultural drainage waters enter the river, neither the coliform nor fecal coliform content of the river is affected to a significant degree by the drainage water. Ratios of concentrations in the river in this area may be influenced more by the far upstream sewage discharges than by the drains. The station locations chosen for the river study are not particularly those that would be selected if the determination of the fecal coliform to coliform percentage was one of the major purposes of this study. Finally, only 13 to 17 samples from each station were analyzed for both coliform and fecal

coliform bacteria. The limited number of results does not support any definite findings of statistical significance.

In the upper reach of the river, downstream from the Redding sewage effluent discharge and downstream from the Red Bluff sewage effluent discharge, the fecal coliform to coliform ratio followed the same general pattern. The median percentage are shown in Table 10.

Table 10

COLIFORM AND FECAL COLIFORM BACTERIA
IN UPPER REACH OF SACRAMENTO RIVER

Miles Below Discharge	Median Percent (Fecal Coliform MPN to Total Coliform MPN)
Downstream from Redding	
2.0	32.2
5.5	38.4
7.7	27.8
10.6	30.8
14.0	31.4
18.8	37.8
28.0	39.2
37.0	29.5
49.5	16.2
Downstream from Red Bluff	
5.0	23.0
8.0	31.5
14.8	26.5
18.8	28.2
25.3	15.4
36.1	19.6
43.7	19.0
58.9	10.0

The results indicate that the percentages remain fairly constant below both discharges for different distances (and times) and then decrease.

This is apparent also in the figure showing the more rapid disappearance rate of the fecal coliform bacteria downstream from the discharges.

The major agricultural drains discharge to the river in the middle reach of the river between river mile 140 and Sacramento. The fecal coliform percentage at seven stations between these two points ranged from 14.7 percent to 28.8 percent with no apparent pattern to the variations. During the August-September sampling period, the river below Sacramento received significant quantities of sewage effluent, cannery wastes, and sugar beet processing wastes. The percentages of fecal coliforms in the river was extremely erratic from station to station and ranged from 10.0 percent at mile 39.9 to 68.6 percent at mile 37.5.

It may be concluded that it was not possible with the data available to find a significant difference in the fecal coliform to coliform percentages in the river water downstream from different types of discharges. The inability to find a difference may be due solely to the limitations of the data. Further work is needed to arrive at a definite conclusion.

Total Numbers of Coliform Bacteria

The total numbers of coliform organisms found in the river and waste discharges of the upper and lower reach are shown in Table 11 and Figure 13 expressed in quantity units. (Quantity units = $\frac{\text{Geometric mean coliform/ml x flow (cfs)}}{1{,}000}$). Quantity units provide a convenient means of comparing total numbers of coliform bacteria by avoiding the awkward use of the high actual numbers of bacteria. The actual numbers of coliform bacteria per day may be obtained by multiplying quanity units x 2.45×10^6.

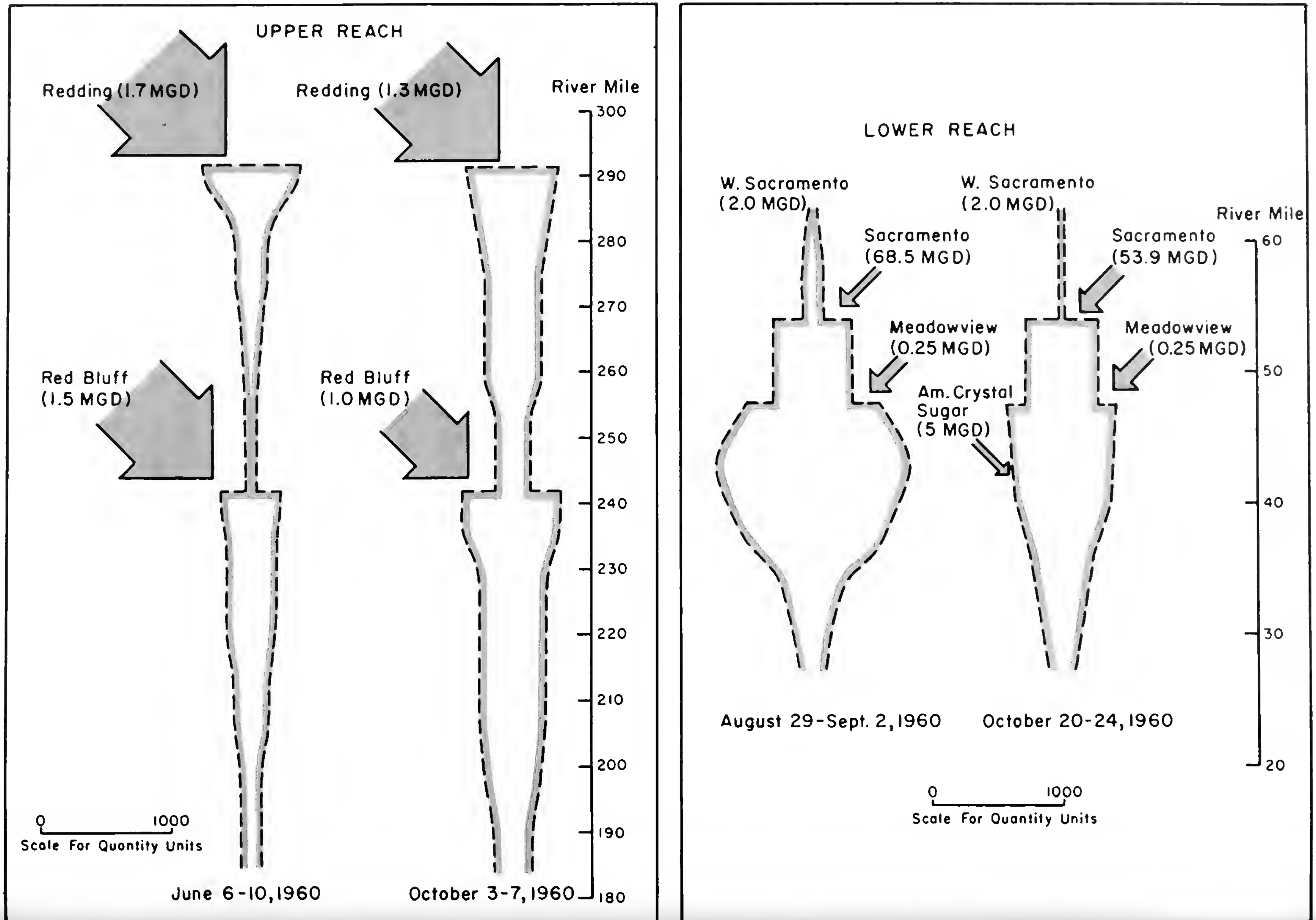


Figure 13. TOTAL QUANTITY UNITS OF COLIFORM BACTERIA IN SACRAMENTO RIVER AND WASTE DISCHARGES

In Table 11 it can be seen that there is a relationship between the numbers of organisms added to the river by the waste discharges in the upper reach and the numbers found in the river downstream. In June, with an average river flow of 8,500 cfs in the area, the total numbers of coliform in the river decreased rapidly. In October, when the river flow averaged 6,000 cfs, the total numbers of coliform below the waste discharges remained fairly high.

The total numbers of organisms found during the August-September and October periods in the lower reach are shown. Very few coliforms are added by the West Sacramento sewage treatment plant discharge because of effective chlorination of the effluent. There was no significant increase of numbers in the river below the plant. Postchlorination at the Sacramento sewage treatment plant has also reduced number of coliforms added by this discharge, however, it can be noted that the increase in coliforms downstream from the discharge is much larger than discharge. The cause of the greater increase was not determined. As was previously mentioned, the sampling point for the discharge from the Sacramento sewage treatment plant may have given low results because of dilution with river water. Also, the river samples which were collected near the surface may have been higher than the average for the river if vertical mixing of the water and sewage was incomplete.

In the August-September period the greatest number of organisms appeared at river mile 43 indicating that there was a growth or increase of coliform in the river from the Meadowview discharge to this point. This increase was not observed in the October period.

The effect of chlorination on the total numbers of coliforms added by the discharges is shown in the figure. West Sacramento provides

Table 11

TOTAL COLIFORM BACTERIA IN RIVER AND DISCHARGES*

River Mile	River	Discharge		Discharge	River
	June 6 - 10, 1960			October 3 - 7, 1960	
293.9	4				16
		997	Redding	808	
291.7	759				770
288.3	687				650
285.9	527				627
283.0	374				598
279.6	271				
275.0	232				429
265.5	153				453
256.3	114				378
244.1	111				271
		708	Red Bluff	467	
238.1	436				743
235.2	381				705
228.4	386				506
224.4	316				506
217.6	310				512
207.1	248				487
199.6	169				428
184.5	167				302
	August 29 - September 2, 1960			October 24 - 28, 1960	
62.6	75.5				32.2
58.2	193				28.5
		0.06	West Sacramento	0.01	
54.1	158				31.1
		45.7	Sacramento	103	
50.9	584				555
48.3	614				539
		85.2	Meadowview	117	
46.2	1020				820
43.4	1490				775
		16.5	Clarksburg	39.3	
39.9	1310				767
37.2	1070				547
34.2	545				452
27.5	222				216

* Figures are in quantity units = $\frac{\text{geometric mean coliform MPN/ml x flow (cfs)}}{1,000}$

effective pre- and postchlorination to greater sewage flows than either Redding or Red Bluff.

Evaluation With Respect to Domestic Use

In Chapter IV of this appendix, Streeter's guide to raw water bacterial quality limits for sources of domestic water supply was presented. The bacteriological quality of the river during each of the six intensive sampling programs was applied to these criteria to find the type of treatment that is indicated for providing a safe drinking water at all points along the river. Since the bacteriological data was collected during a four-day period, no monthly average is available; however, the degree of treatment indicated for the critical periods that were investigated can be found by applying the arithmetic averages for these periods to the criteria. It might be well to reiterate that the California State Department of Public Health does not base its requirements for water treatment on this or any other "cut and dried" set of raw water quality standards. The presentation here is merely another way of looking at the bacteriological quality of the river. Figure 14 pictorially shows the treatment requirements based on Streeter's guide for the upper, middle, and lower reaches of the river.

The type of treatment indicated for the upper reach reflects the greater degradation in bacteriological quality during the October sampling period. The waters below Redding in that period fall in Streeter's lowest classification, those requiring prolonged storage or some other means of bringing the coliform concentrations down to treatable levels prior to complete treatment.

In the middle reach, the bacteriological content requires at least filtration and postchlorination, but the effects of the agricultural

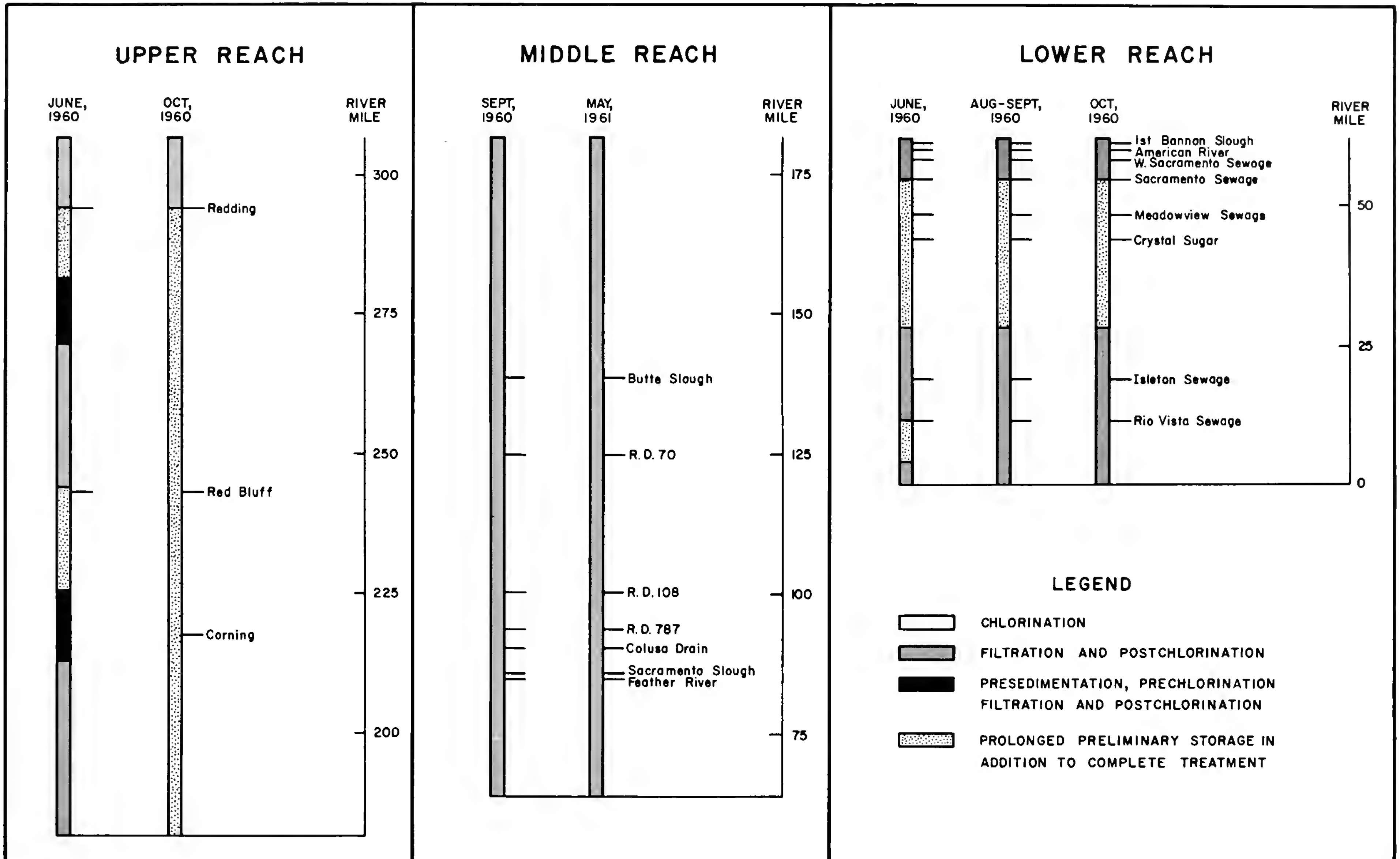


Figure 14. MINIMUM WATER TREATMENT REQUIREMENTS BASED ON STREETER'S GUIDE*

* From "Standards of Raw and Treated Water Quality" Jour. AWWA (1939)

drainage waters apparently have not had a significant effect on the need of treatment.

The lower reach showed almost the same minimum treatment requirements for all three critical periods. Although the point at which a recovery of quality depicted by a lessening of minimum treatment requirements appears much closer to the Sacramento discharge than at Redding or Red Bluff, the actual travel times to the points of recovery are similar.

Bacteriological Quality of Present Domestic Water Supplies

There are five domestic water systems that presently use the Sacramento River as a source of supply. Three of these have intakes located in the Redding area above the city's sewage discharge. The river water above the Redding sewage discharge is of good bacterial quality, except during periods of storm runoff from local watersheds between Lake Shasta and Redding. During June 6 - 10, 1960, and October 3 - 7, 1960, the average coliform MPN value of 32 samples collected in each period was 76/100 ml and 201/100 ml, respectively.

The City of Redding provides chlorination and settling. During storm flows, alum may be added to aid turbidity removal. The water served to the consumers has consistently met the bacteriological requirements of the U. S. Public Health Service "Drinking Water Standards".

The Rockaway Water System serves a small subdivision of 24 homes. The diverted water is chlorinated prior to distribution. Monthly samples taken from the system have occasionally failed to meet the bacteriological requirements of the "Drinking Water Standards".

The Enterprise Public Utility District obtains a part of its supply from an infiltration gallery below the river bed. The water is chlorinated prior to distribution. Bacteriological samples taken from

the distribution system have consistently met the "Drinking Water Standards".

The City of Sacramento has an intake on the Sacramento River a short distance below the confluence of the American River. The water entering the intake may be from either river, depending on flow conditions and local currents. The untreated water is sampled routinely by the city and the average coliform content for 1960 was a MPN of 3,000/100 ml. The monthly coliform MPN average ranged from 460/100 ml - 7,000/100 ml.

The water is given complete treatment; prechlorination, flocculation, sedimentation, lime treatment, filtration and postchlorination. The treated water has consistently met the U. S. Public Health Service "Drinking Water Standards".

The City of Vallejo diverts water from Cache Slough, a waterway branching from the Sacramento River. The raw water quality in the slough is affected by agricultural drainage and the storm flows from numerous intermittent creeks. The water is chlorinated for slime control at the point of diversion and is then piped to two plants; one serving Travis Air Force Base and the other at Vallejo. The plants provide prechlorination, flocculation and sedimentation, filtration, fluoridation, postchlorination, and pH adjustment. The treated water has consistently met the U. S. Public Health Service "Drinking Water Standards".

Water Contact Sports

The Sacramento River is the site of many types of recreational activities. In the course of certain activities the public comes in contact with the water, and consequently, the water quality becomes an environmental factor that may affect the public health. Waterskiing, swimming, and wading are such "water-contact" sports.

In order to protect the public from water-borne diseases while engaged in water-contact sports, health agencies of many states have proposed various coliform bacteria limits for acceptable bathing water. However, there is little epidemiological evidence available on which to base the limits. Bacteriological treatments that have been established range from an arithmetic average coliform MPN of 50/100 ml to 3,000/100 ml. Accordingly, arithmetic averages of MPNs have been computed and are discussed below in connection with reaches of the river where water-contact sports are significant.

In inland waters, significant numbers of coliform originating from non-fecal sources are often present. The application of a common coliform standard to inland waters containing high numbers of such coliform could be unnecessarily restrictive and yet the limit might not be adequate where a sewage discharge is the predominant source. For these reasons California has not established a coliform bacteria limit for water-contact sports areas in inland waters. Due to the degree of differentiation provided by the fecal coliform test, a common standard based on this group of indicator organisms might be possible, and is worth further investigation.

Hamilton City to Rio Vista

On Labor Day weekend, September 3 - 5, 1960, a survey of recreational use was conducted by boat from Hamilton City to Rio Vista. One phase of the survey was to determine the location of popular water-contact sports areas and the numbers of people engaged in these sports. In the entire area surveyed, 285 persons were observed wading, swimming or water-skiing. The total daily use is undoubtedly much greater than that observed at one moment in the day, as was the case in the survey. The location

of the persons is shown in Figure 15. Most of the activity was observed in the lower portion of the river. It was not possible to observe all areas during the hours of maximum use, however, in spite of the time of observation, certain points along the river attracted large numbers of people and were quite evidently the most popular water-contact sports areas. Four popular sites were: the mouth of the Feather River, Clay Bank Bend (five miles below Sacramento), Steamboat Slough and the Isleton area. Numbers of persons engaged in water-contact sports and arithmetic averages of coliform and fecal coliform bacteria in these areas are shown in Figure 15. The bacteriological quality of the water in Steamboat Slough, which is joined at both ends to the Sacramento River, was estimated from the quality in the river at the ends.

The poorest bacteriological quality for the popular water-contact sports areas was at Clay Bank Bend which is immediately below the Sacramento sewage treatment plant outfall. The coliform bacteria content in this area exceeds the most liberal bacteriological standards for a water-contact sports areas.

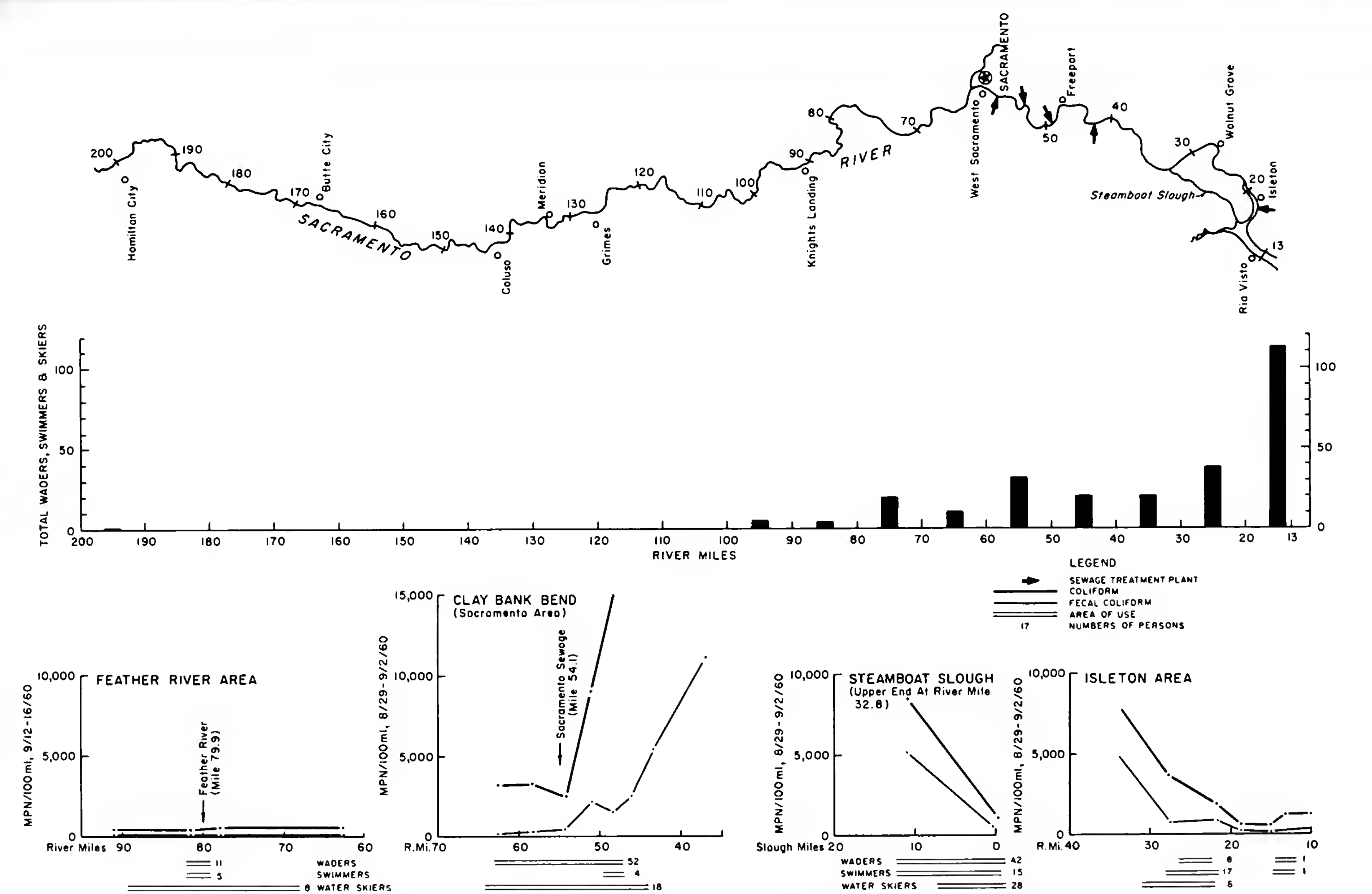


Figure 15. WATER-CONTACT SPORTS AND BACTERIOLOGICAL QUALITY
Hamilton City To Rio Visto

Redding to Hamilton City

The recreational use of the river from Redding to Butte City was obtained from studies made by the Department of Public Health in 1953, 1956, and 1960. Data shown in Table 12 obtained from resort owners revealed that the use of the river for water-contact sports had increased greatly in the four-year interval between 1956 and 1960 despite the less favorable water temperatures in the area (55° - 65°F).

Table 12

PUBLIC USE OF RECREATION FACILITIES
REDDING TO BUTTE CITY

Year	Number of Resorts	Number of County Parks	Swimmers*	Water-Skiers*
1953	9	1	No Data	No Data
1956	22	1	45	154
1960	21	4	110	418

* Maximum number of persons/day.

The most popular water-contact sports areas from Anderson to Redding are shown in Figure 16. Above Anderson there is very little use of the river for water-contact sports. Also shown on the figure are the greatest numbers of water-skiers and swimmers that were in the areas on any one day. These numbers were obtained from resort owners near the end of the recreational season.

The coliform and fecal coliform bacteria content of the river in these popular water-contact sports areas are shown in Figure 16 with the location of the resorts that reported swimmers and water-skiers.

In the Red Bluff area the bacteria in the river represents the residual effects of the Redding discharge which enters the river 50 miles

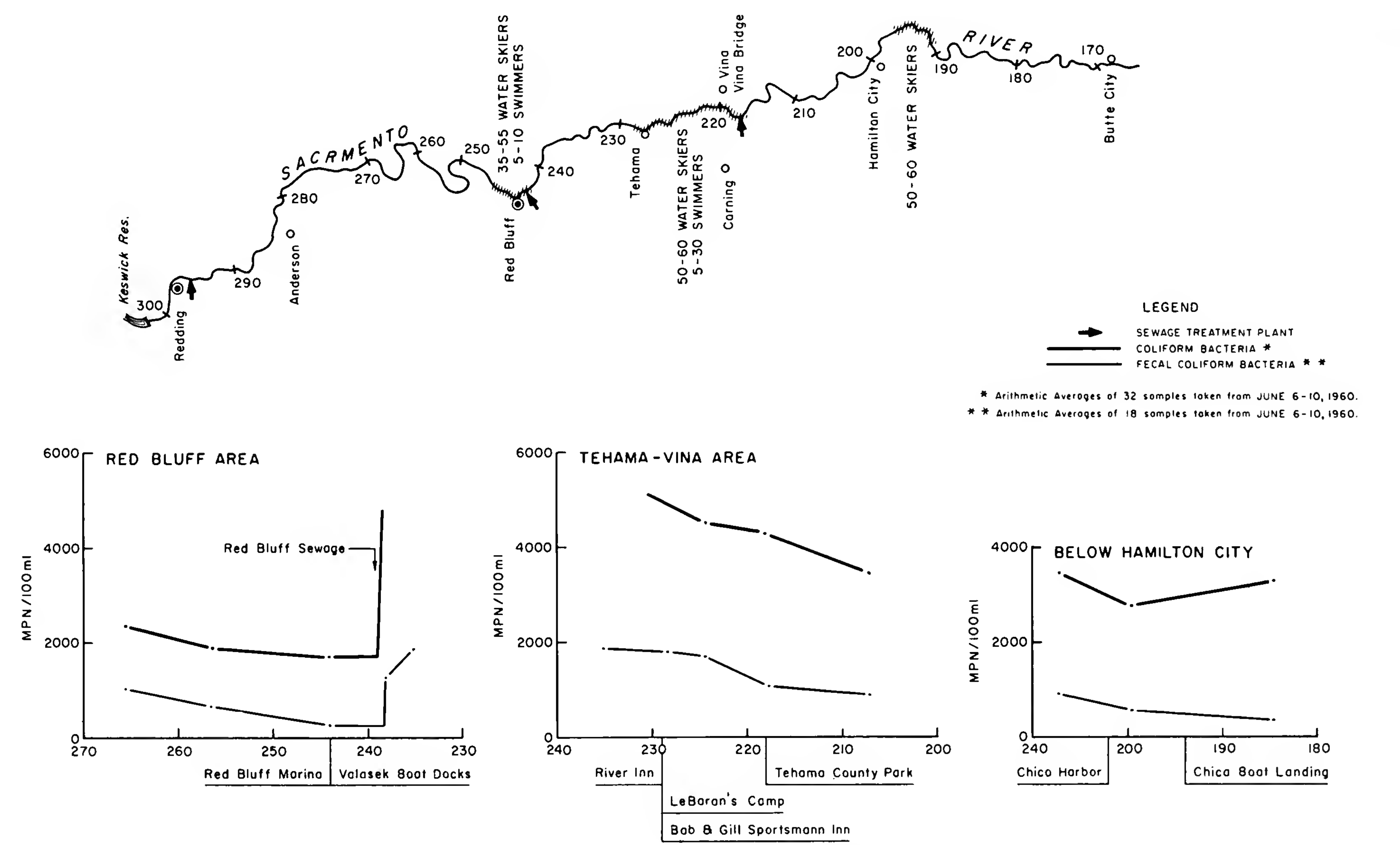


Figure 16. WATER-CONTACT SPORTS AND BACTERIOLOGICAL QUALITY
Redding To Butte City

upstream. The Red Bluff sewage discharge enters the river below the water-skiing area. The Tehama-Vina area and the area below Hamilton City is affected by the Redding and Red Bluff sewage discharges. The Corning discharge is normally confined to land during the recreational season. If sewage effluent from the Corning primary treatment plant is discharged to the river at any time during the recreational season, from May through October, it is chlorinated.

CHAPTER VI. CHEMICAL AND PHYSICAL QUALITY

The chemical quality and physical characteristics of the Sacramento River are discussed in detail in Appendix B. In this chapter the remarks will be limited to a general discussion of the quality as it is related to the use of the water for domestic purposes.

Chemical Quality

In Chapter IV, the U. S. Public Health Service "Drinking Water Standards" of 1946 were presented as the quality guide used by the State Department of Public Health in evaluating the chemical quality of drinking water. The analyses of monthly samples collected at 22 points along the river allow a comparison of the various chemical constituents to the Drinking Water Standards.

Constituents With Maximum Allowable Limits

Arsenic (Limit - 0.05 mg/L). Range of river analyses: 0.00 - 0.01 mg/L. With the exception of results from a single sample taken at Bryte, above Sacramento, all chemical analyses for arsenic reported 0.00 mg/L.

Hexavalent Chromium (Limit - 0.05 mg/L). Range of river analyses: 0.00 - 0.01 mg/L. A few samples collected at widespread points along the river reported 0.01 mg/L. The great majority of samples analyzed reported 0.00 mg/L.

Lead (Limit - 0.1 mg.L). Range of river analyses: 0.00 - 0.03 mg/L. A few samples from the lower end of the river reported the presence of lead in insignificant amounts. All other samples reported 0.00 mg/L.

Fluoride (Limit - 1.5 mg/L). The State Board of Public Health has established a limit of 1.0 mg/L in areas where the mean annual air temperature is 60°F. Mean annual air temperatures for 30 years of record for eight stations from Sacramento Redding range from 60.0 to 63.2°F. Range of river analyses: 0.0 - 0.3 mg/L. Samples collected at six stations from Sacramento to Rio Vista reported 0.3 mg/L in July 1960. Otherwise values ranged from 0.1 - 0.2 mg/L with occasional reports of 0.0 and 0.3 mg/L.

Constituents With Maximum Recommended Limits

Copper (Limit - 3.0 mg/L). Range of river analyses: 0.00 - 0.13 mg/L. The presence of copper appeared in samples taken from the extreme northern end of the river in the Spring Creek area. Spring Creek contains mine drainage water having high concentrations of heavy metals. The range of copper found in Spring Creek was from 3.9 to 11.0 mg/L. However, the effect on the Sacramento River was not significant from a public health standpoint.

Zinc (Limit - 15.0 mg/L). Range of river analyses: 0.00 - 0.10 mg/L. The presence of zinc was also noted in the river below Spring Creek. Samples from the middle and lower reaches constantly had 0.00 mg/L in the samples collected. The maximum value found in the Sacramento River in the vicinity of the Redding water intake was 0.09 mg/L.

Iron and Manganese (Combined Limit - 0.3 mg/L). Range of river analyses: 0.0 - 0.32 mg/L. The higher levels of iron and manganese were found in the northern area with low values reported downstream from Ord Ferry. Spring Creek contained 55 to 305 mg/L iron and 0.4 to 2.6 mg/L manganese during the sampling period. The maximum reported combined

concentration of iron and manganese was 0.32 mg/L near the Redding water supply intake. These were the only occasions that the maximum suggested limit was exceeded in the entire river.

Chloride (Limit - 250 mg/L). Range of river analyses: 2 - 927 (mg/L. The chloride content of the river above Rio Vista generally contained 10 mg/L or less of chlorides. Downstream from Rio Vista, in the area affected by the invasion of bay waters, the chloride concentration was usually in the hundreds of mg/L.

Sulfate (Limit - 250 mg/L). Range of river analyses: 2 - 144 mg/L. Above Rio Vista the normal sulfate concentration was less than 20 mg/L. In the tidal zone below Rio Vista higher values were reported due to the influence of bay waters.

Magnesium (Limit - 125 mg/L). Range of river analyses: 0 - 67 mg/L. Above Rio Vista the magnesium content of the river was less than 8 mg/L. In the area below Rio Vista the bay water influence resulted in a rise of 20 to 60 mg/L.

Phenolic Compounds (Limit - 0.001 mg/L). Range of river analyses: 0.000 - 0.01 mg/L. The limit for phenolic compounds was exceeded on 13 occasions and equaled on 16 other occasions. These occurrences were often in areas where there was no nearby discharge to account for their presence. The compounds may result from natural sources, however, the high values are more likely due to the limitations of present test methods.

Dissolved Solids (Limit - 500 mg/L desirable; 1,000 mg/L permissible). Range of river analyses: 60 - 1,930 mg/L. Above Rio Vista

the dissolved solids content was less than 160 mg/L. In the area of tidal influence the values were greatly increased.

In reviewing the general trend of concentrations of various chemical constituents in the river, there appeared to be two definite sources. In the uppermost reach, Spring Creek contributed heavy metals to the river. The dilution afforded by the Sacramento River kept the values of these constituents at low levels in the river. The influence of bay waters increased the chloride, sulfate, magnesium and dissolved solids content below Rio Vista.

Corrosion Potential

One property of water that is particularly important to the domestic water supplier is the tendency of the water either to corrode ferrous metals or to deposit calcium carbonate. The Langelier "saturation index" indicates the tendency of the water to do one or the other[21]. A positive index indicates that a calcium carbonate film will be deposited on the interior of water mains; a negative index indicates that the water will possibly corrode metal pipes.

Typical values of the Langelier "saturation index" for several locations of the Sacramento River are given in Table 13.

Table 13

LANGELIER SATURATION INDEX
OF SACRAMENTO RIVER WATER

Location	River Mile	Saturation Index
Redding	294	-1.9
Red Bluff	244	-1.8
Hamilton City	200	-1.6
Butte City	168	-1.5
Knights Landing	91	-1.4
Bryte	63	-1.6
Freeport	46	-1.8
Rio Vista	12	-1.7
Mayberry Slough	4	-1.6

The values in Table 13 indicate that the water has an appreciable negative index and would tend to be corrosive unless proper treatment is applied. The problem of corrosion at Redding is aggravated during periods of storm runoff when acid mine drainage entering the Sacramento River from Spring Creek depletes the already low alkalinity in the river. The corrosive tendencies may be controlled by an upward adjustment of pH by the addition of lime [$Ca(OH)_2$]. The City of Redding has recently installed chemical feed equipment for the addition of lime to reduce the corrosive tendencies of the water. Sacramento began lime treatment in May 1960, and Vallejo has been adding lime to the treated water for several years.

Hardness

Hardness is a property of water that may cause problems in domestic use. Hardness is principally due to calcium and magnesium and when present in high amounts will inhibit soap lathering and cause unsightly curds. Scale deposits will also form in hot water pipes. The U. S. Geological Survey classifies waters of various degrees of hardness as follows [22]:

Hardness (ppm)	Remarks
0 - 60	Soft
61 - 120	Moderately hard
121 - 200	Hard
Above 200	Usually requires softening

By this classification, the waters of the Sacramento River during the survey period were generally soft above Colusa and soft to moderately hard between Colusa and the Delta Cross Channel.

Physical Quality

The U. S. Public Health Service "Drinking Water Standards" of 1946 has set the following maximum allowable limits for the physical characteristics of drinking water delivered to the consumer [12].

Turbidity (silica scale)	10 ppm
Color (platinum - cobalt scale)	20 units

The water shall have no objectionable taste or odor.

The concentrations of turbidity in the entire river during periods of storm runoff range from 50 - 100 ppm with peaks of 350 ppm. Except for these periods, the lowest turbidities, ranging from 2 - 10 ppm, were found in the Redding area. The turbidity in the river is increased by the agricultural drainage water in the middle reach. At Sacramento,

the average turbidity range is 20 - 25 ppm. In the tidal area below Rio Vista the turbidity is increased up to 120 ppm.

The concentration of color in the river was highest during storm flow periods when 30 - 50 units were reported. In dry weather, the river from Redding to Rio Vista ranged from 5 - 20 units. Below Rio Vista, the color range was 10 - 30 units.

The threshold odor numbers for the river water ranged from 2 to 8 with a few higher values. These values would probably not result in consumer complaints, however, local land drainage and industrial discharges can and do cause odors in local areas where complete mixing with the river water has not occurred.

In conclusion, the river water from Keswick Dam to Rio Vista meets the requirements of chemical characteristics for a domestic water supply of the 1946 U. S. Public Health Service "Drinking Water Standards". The water exhibits an aggressive tendency over the entire river and treatment for corrosion prevention would be desirable. No need for water softening is indicated.

The generally good physical properties of the river water are greatly affected during storm runoff periods. Because of this, the water requires treatment to bring the physical properties within the limits of the U. S. Public Health Service "Drinking Water Standards".

Chemical and Physical Quality in Present Domestic Water Systems

The chemical and physical quality of the water at the present domestic water system intakes is subject to seasonal variations and local influences that have caused consumer complaints and treatment problems.

City of Redding Water System

The major variations in raw water quality at Redding are changes in turbidity and alkalinity. High turbidity occurs in period of seasonal rains as result of runoff, and low alkalinity results during the same period from the influence of Spring Creek which carries acid mine drainage.

The turbidity has caused consumer complaints and higher chlorine demands along with operating difficulties at the treatment plant. The low alkalinities have caused the water to be even more "aggressive" than usual resulting in corrosion problems and "red water" complaints. Taste complaints caused by overchlorination have been reported. Color and taste complaints have resulted from the corrosive water and repots of sand in the water have resulted from turbidity carryover into the distribution system.

The city has recently added a lime feeder to correct the problem of corrosion and has redesigned equipment in the settling reservoir to improve efficienty of turbidity removal.

Rockaway Estates Mutual Water System

In spite of the fact that no treatment other than chlorination is given the water, there have been few complaints regarding taste, odor, color or turbidity. This may be attributed to two factors: first, the residents have been consuming the water for a number of years and may have come to accept taste and odor without comment and second, since this is a mutual system, any additional treatment facilities would have to be paid directly by the residents.

The major variation in the quality of water taken into the system is in turbidity. Since no settling or other means of removing turbidity is provided in the system, the amount of turbidity is virtually

the same as for the river becoming a maximum after storms and a minimum during the summer months when there is no storm runoff.

A regular occurrence of a "fishy" odor is noted in the water system during the fall salmon runs. The water system operator believes that this is due to dead and rotting fish near the mouth of the intake. Only one complaint from a consumer regarding taste, odor or turbidity has been reported in the last three years.

Enterprise Public Utility District Water System

The only variation in chemical and physical water quality taken from the system infiltration gallery on the Sacramento River is in turbidity. Increases in turbidity occur during seasonal rains, however, ground water sources of supply may be used during these periods.

Numerous occurrences of tastes and odors were reported in the distribution system in 1959, however, these were attributed to two new wells which have recently been constructed. No taste and odor problems have been attributed to the Sacramento River water.

City of Sacramento Water System

The quality of the raw water at Sacramento has been affected in the past by sewage and industrial waste discharges in the area immediately north of Sacramento, rice field drainage, and storm runoff.

One of the major contributors to tastes and odors in the Sacramento water supply has been the flow from the Natomas Drain. The drain receives water from several small creeks which carry the discharges from a number of sewage and industrial waste treatment plants. In the past, the cause of phenolic compounds in the drain has been attributed to discharges at McClellan Field which includes wastes associated with airplane maintenance, and the Sacramento County Sanitation District No. 6

plant which treats waste water from the McClellan Field laundry. A "closed system" is now in operation at the field so that only a minimum flow of wastes containing phenols is discharged through the sewage treatment plant at the field. A constant monitoring program is carried out to detect fluctuations in the phenol concentrations of the receiving waters. A seasonal occurrence of tastes and odors has been experienced at Sacramento after the first heavy rains. These seasonal occurrences are believed to be caused by organic material that has collected in the small creeks during the year. The first high flows in the creek flush the material into the Sacramento River immediately upstream from the water intake. A recent study by the city has revealed that tastes and odors in the water system may have also resulted from the presence of Actinomycetes in algal growths on the sand filters.

<u>Specific Occurrence of Tastes and Odors</u>. 1953 - Two incidents of tastes and odors occurred in the city system. These were attributed, in part, to a discharge of cresylic acid from McClellan Field. The industrial waste discharge at McClellan Field at that time included wash water from a vehicle shop, solvent still and paint washer.

1958 - An incident resulting in sewage contamination of the American River and the city raw water supply occurred in May. On May 23, a section of the sewer that carried sewage from the North Sacramento and Hagginwood Sanitation Districts to the Sacramento system collapsed. Until July 13, while repairs were being made, the districts were required to dispose of their sewage by other means. Hagginwood discharged 0.9 MGD raw sewage first to Arcade Creek and then to the American River. North Sacramento also discharged 0.5 MGD of raw sewage to the American River. The discharges entered the river three miles above the water intake. The sewage was chlorinated at pumping stations at the rate of 13.9 mg/L

for Hagginwood and 9.2 mg/L for North Sacramento, however, the dosage was insufficient to result in a residual. Fortunately the City of Sacramento has recently completed the installation of prechlorination equipment at the filtration plant. A chlorine dosage of 3.0 mg/L was applied to the raw water from May 25 to July 15. No coliform bacteria were found in the treated water and no transmissions of disease were attributed to the incident. Tastes and odors were reported in the systems, probably due to the higher degree of chlorination.

1959 - Taste and odors developed in the water system during December 24 and 25. Prechlorination residuals dropped from 0.6 to 0.05 mg/L at a steady dosage rate of 1.5 mg/L. There was a general rain in the area during this period and an investigation disclosed that the creek receiving the McClellan Field discharge contained 11 parts per billion of phenols at its mouth. It is believed that the phenolic compounds held in the backwaters and along the banks of the creek were flushed out with the storm water.

1960 - After the first heavy rains of the winter season in November, taste and odors were reported in the distribution system. The cause was believed to be the same as for 1959, that is, the flushing of phenolic compounds in the small creeks discharging to the Natomas Drain.

During each occurrence of tastes and odors, the record of consumer complaints followed the same general pattern. For a period of approximately one week; 30 to 40 reports per day are received at the water department. The number gradually decreases over the next few weeks. The total period for which tastes and odors are reported averages one month. Chlorine dioxide treatment is being considered by the city to eliminate the odor problems.

During the rice field drainage period in September, an increase is found in the alkalinity and chlorine demand of the raw water at the filtration plant. No other constituents of the water appear to be changed to any appreciable degree.

Peak turbidities of 350 units have been recorded for short periods in the raw water during periods of storm runoff. After complete treatment no turbidity has been found in the finished water.

City of Vallejo Water System

The quality of the water in Cache Slough is affected by agricultural drainage and storm runoff. During periods of rain the turbidity at the intake may exceed 250 units. Activated carbon can be added to the water at the Fleming Hill treatment plant to control tastes and odors, however, this is usually not necessary. The water is aggressive and its corrosive tendency is controlled by pH adjustment. Few complaints of chemical or physical quality are reported.

CHAPTER VII. PLANKTON

A total of 265 samples from 22 stations were examined for the enumeration of plankton. Samples were collected on a monthly basis. Economic limitations required a reduction in the number of samples collected and analyzed during the last six months of the survey, however, no station had fewer than nine samples analyzed. Table 14 shows a list of the sampling stations and the distribution of samples with time.

Quantitative Aspects

Quantitative data, by station, are presented in Table T-2 at the end of this appendix. Meaningful graphic presentation of these data by conventional means [23] is difficult. To resolve this problem, a modification of the isometric plotting method used by ORSANCO [24] was developed. By means of this technique the simultaneous presentation of three variables, in this instance, time (sampling month), place (sampling stations by river mile), and the number of plankton, can be made. Figure 17 summarizes graphically the data included in Table T-2.

Inspection of Figure 17 shows remarkable changes in plankton population which occurred as a function of time of year and downstream movement of the water. These changes in the total number of plankton are shown more simply but less accurately in Figure 18.

In the upper portion of Figure 18, the total number of plankton reported for each station was averaged over the time of the entire survey and over selected months to show plankton changes with distance. Averaging in this way is not quantitatively valid since all stations were not sampled during all months. The resulting averages may therefore be biased with respect to the season or seasons during which the samples

Table 14

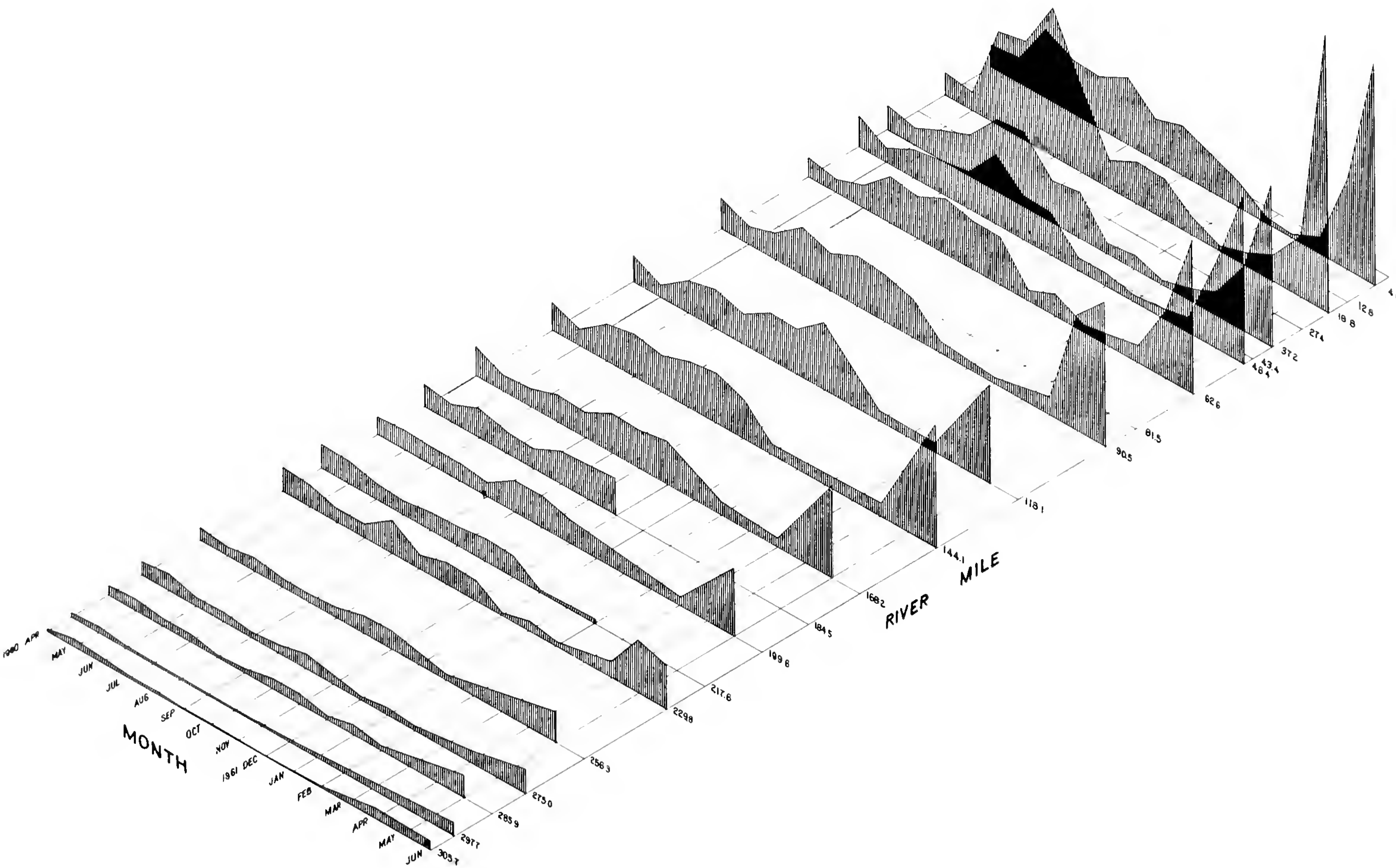
SACRAMENTO RIVER STUDY - PLANKTON SURVEY
PLANKTON SAMPLING, STATIONS AND SAMPLE DISTRIBUTION

Station No.	Station Location	River Mile	1960 Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1961 Jan.	Feb.	Mar.	Apr.	May	June	Total Number of Samples
1	Above Spring Creek	305.7	x	x	x	x	x	x	x	x			x		x		x	11
2	Above Redding Diversion Dam	297.7	x	x	x	x		x	x	x	x	x					x	10
5	Above Churn Creek	285.9	x	x	x	x	x	x	x	x	x	x	x			x		12
6	Balls Ferry Bridge	275.0	x	x	x	x	x	x	x	x	x	x	x		x		x	13
7	Bend Bridge	256.3	x	x	x	x	x	x	x	x		x				x		10
10	Above Elder Creek	229.8	x	x	x	x	x	x	x	x	x	x	x		x	x	x	14
11	Vina Bridge	217.6	x	x	x	x	x	x	x	x	x		x					10
12	Hamilton City Bridge	199.6	x	x	x	x	x	x	x	x			x			x		10
13	Ord Ferry	184.3	x	x	x	x	x	x	x	x						x		9
14	Butte City Bridge	168.2	x	x	x	x	x	x	x	x		x		x		x		11
15	Colusa Bridge	144.1	x	x	x	x	x	x	x	x	x				x		x	11
16	Below Wilkins Slough	118.1	x	x	x	x	x	x	x	x		x		x		x		11
17	Above Colusa Basin Drain	90.5	x	x	x	x	x	x	x	x	x		x		x	x	x	13
19	Above Sacramento Slough	81.5	x	x	x	x	x	x	x	x	x	x		x		x		12
20	Bryte Laboratory	62.6	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
22	Freeport Bridge	46.4	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
23	Above Clarksburg	43.4	x	x	x	x	x	x	x	x						x		9
24	Snodgrass Slough	37.2	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
25	Above Delta Cross Channel	27.4	x	x	x	x	x	x	x	x		x		x		x		11
26	Isleton Bridge	18.8	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
27	Rio Vista Bridge	12.8	x	x	x	x	x	x	x	x	x	x	x		x		x	13
28	Above Mayberry Slough	4.0	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	15
																		265

Figure 17

SACRAMENTO RIVER. PLANKTON, TOTAL PLANKTON PER ML
BY MONTH AND STATION

VERTICAL SCALE : EACH SCALE DIVISION = 100 PLANKTON PER ML



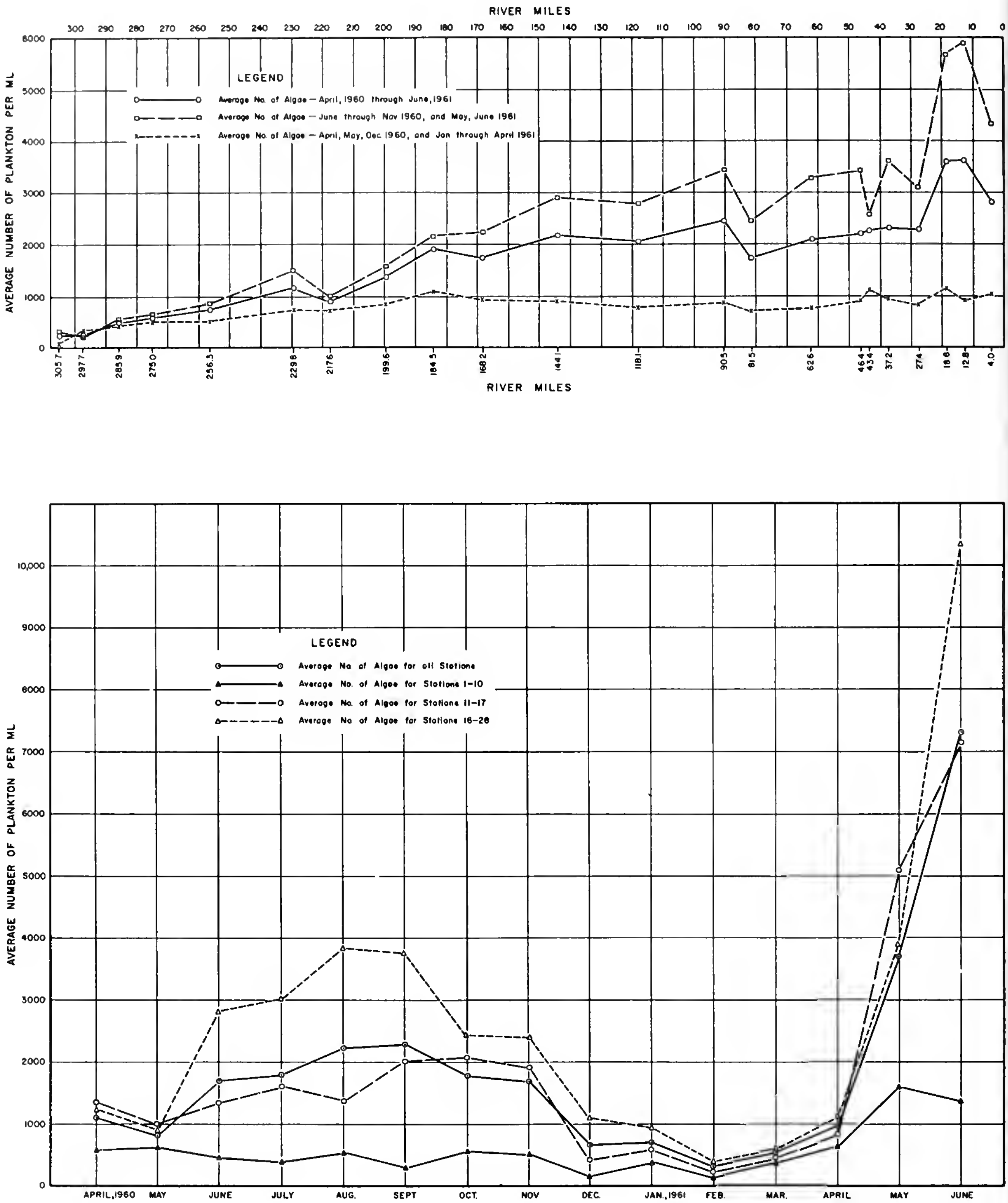


Figure 18. AVERAGE TOTAL PLANKTON POPULATION IN SACRAMENTO RIVER

were collected. Nonetheless the general trend of changes in plankton population is clearly shown. As the river progressed downstream, there was a gradual but definite increase in the number of plankters. A relatively great increase in plankton occurred at river mile 18.8, a point about 35 miles downstream from the sewage discharge of the City of Sacramento.

When averages at each station are made on a seasonal basis, the warmer months (June, July, August, September, October, November 1960 and May and June 1961) showed even more sharply the plankton increase with downstream travel and the maximum at Isleton Bridge (river mile 18.8) and Rio Vista Bridge (river mile 12.8). The colder months (April, May, December 1960 and January, February, March and April 1961) showed a slight increase during the upper hundred miles of the river then an essentially unchanged plankton population for the remaining 200 miles of the river.

In a similar way, the lower portion of Figure 18 shows plankton variations with time in that the total number of plankton for all stations was averaged for each month and selected stations were averaged for each month. Again the objections to such averaging mentioned above are pertinent yet the gross picture is informative. As the year progressed to the warmer seasons with more sunlight, the average number of plankton for the whole river increased. In 1960 this increase began in June, reached a peak in September and declined to a minimum during the months of December through March. In 1961, there was an earlier development of the plankton (May rather than June). Although, the study was not continued long enough to establish the peak of the plankton curve for 1961, the river average for June 1961, was almost four times that for the peak in September 1961.

Correlation of Stream Conditions with Total Plankton Populations

Various authors have attempted to correlate plankton populations in rivers with physical and chemical attributes of the river. One of the earlier students of river plankton wrote what has since been termed Schröder's Law, namely, that the amount of plankton in running water is inversely proportional to river slope (25). In his monumental study of the Illinois River, Kofoid (26) concluded that age of the water was an important factor in plankton production. Young waters from springs and creeks were relatively barren. Impounded waters, on the other hand, were rich in plankton. Kofoid considered that the most immediately effective factor in the environment of stream plankton was fluctuations in the stream's hydrographic conditions. Rising stream levels produced sharp declines in plankton content whereas falling levels were periods of increase in plankton. Hydrographic stability was conducive to high production and instability was always destructive to plankton. Temperature too, affects plankton profoundly; for example, at temperatures below 45°F the plankton content was only 9 percent of that found at higher temperatures. At temperatures of about 80°F or higher production again fell to 44 - 87 percent of the maximum. Still another factor considered by Kofoid was light. He showed that the half-year with more illumination and fewer cloudy days produced 1.6 to 7 times as much plankton as the less well lighted half-year.

Allen (27) studied the San Joaquin River and concluded that temperatures, within certain limits, was the determining factor in seasonal distribution of plankton. He considered that sewage additions stimulated growth and water currents above a moderate rate were inimical to plankton development. Wundsch (28) similarly concluded that the temperature effect was a primary one.

On the other hand, Galstoff [29] who studied the Upper Mississippi River wrote that current velocity was the principal factor affecting life in a river. Reinhard [30] who also studied the Upper Mississippi River, considered various physical, chemical and biotic factors. Of the physical factors he wrote "It may be said that if other conditions are equal, the productivity of a stream is proportionate to the age of its water and inversely proportionate to its velocity". Among the chemical factors mentioned were water hardness and silica content. The principal biotic factors were predators and biological competition.

Roach [31] studied another midwestern stream, the Hocking River in Ohio, and concluded that "of the factors studied, light, acidity, current, chemical condition of the water, and temperature, only the latter two showed variation that corresponded with changes in plankton". He felt that plankton could not be used as an index of pollution. Coffing[32] worked on the White River Canal at Indianapolis, Indiana and observed that although the plankton maxima were not definitely correlated to temperature, in general, plankton production and temperature were fairly well correlated. Diatoms especially, followed the temperature curve. She concluded that "in general, temperature seemed to be a primary factor influencing plankton production".

In England, Rice [33] studied the Thames River and related the phytoplankton to the water level. He observed that plankton numbers varied inversely with river current. The nitrate content of the water also had a marked effect on productivity. Brinley and Katzin [34] who studied the Ohio River system concluded that while temperature was an important determinant in plankton growth, organic pollution was probably more significant. Lackey, Wattie, Kachmar, and Placak [35] also felt that the greatest potentially modifying factor in unpolluted streams was the entrance

of sewage. This conclusion was reached despite the observations that phosphorus and nitrogen might seldom be limiting because such low concentrations were necessary for maximum plankton growth.

Pennak [36] in 1946 reviewed much of the literature on factors affecting fresh water plankton and wrote:

> "As recently as 20 years ago it was widely held that plankton populations were controlled, quantitatively and qualitatively, by some one or several obvious environmental factors, such as pH, oxygen, carbon dioxide, nitrates, and temperature. As more and more work has been done, however, it has become apparent that the plankton ecosystem is far more complicated than most earlier workers had imagined, and that factors previously regarded as limiting factors in themselves are now regarded as being of little importance. Present tendencies are directed toward the study of the interreactions of many factors with special emphasis on some of the less obvious and less easily measured factors, such as the probable significance of 'trace' elements and biochemical relationships between organisms."

With respect to the importance of trace nutrients the work of Hutchinson on thiamin [37] and niacin [38] and Rohde [39] on nitrogen, phosphorous, iron, magnesium, and potassium may be cited.

From the foregoing review it is obvious that a wide variety of environmental factors has been considered as affecting plankton development. Unfortunately, none of the previous workers were able or attempted to relate these environmental factors to plankton on a quantitative basis. Such an attempt follows.

The quantitative problem can be approached first, graphically by means of scatter diagrams and second, mathematically by use of regression analysis. To simplify the massive task of making computations, data from a limited number of stations were selected for analysis. These stations and the selected data are shown in Table T-3 at the end of this appendix. Unfortunately, adequate flow data below Sacramento is unavailable, therefore, correlations involving flow were made at only the first

eight selected stations. Correlations of plankton, temperature, and BOD were made at all 10 selected stations.

Ideally multiple regressions should be evaluated simultaneously for all variables. Manual computation is possible only with three variables; inclusion of more variables requires the use of a computer which was not available. For this reason, only two multiple regressions were computed, namely for plankton count, temperature, and flow and plankton count, temperature and BOD. Visual inspection of the other data included in the tables and the use of selected scatter diagrams indicated the unlikelihood of significant correlations with plankton by any of the other tabulated parameters of stream conditions.

Plankton, Temperature, and Flow

The data used in this computation were eight sets of observations of two independent variables, temperature and stream flow, and one dependent variable, plankton count (Tables 36 - 43). A relationship among these variables was assumed:

$$Y = A + B_1 X_1 + B_2 X_2$$

where Y = log plankton count (number/ml)
X_1 = log temperature (°F)
X_2 = log stream flow (cfs x 10^{-3})
and A_1 B_1 and B_2 are constants

Following standard theory and computation procedures for multiple regressions [40] the equation, using the eight sets of observations taken together rather than individually, was solved to give $Y = -5.0664 + 4.6882 X_1 - 0.2168 X_2$ with a coefficient of multiple correlation of 0.686. This is interpreted as meaning that $(0.686)^2$ or 0.471 is the proportion of the total variations which can be attributed to variations in temperature and stream flow. In other words, the changes in temperature and stream flow account for 47.1 percent of the changes in plankton count.

Using an appropriate (F) test for significance of this correlation coefficient it was found that the value is significant at the one percent level or, stated differently, a correlation coefficient of this magnitude cannot be attributed to chance.

Inspection of the equation $Y = -5.0664 + 4.6882 X_1 - 0.2168 X_2$ and the calculations used in deriving it, show that the correlation between stream flow (X_2) and plankton count (Y) is small. To evaluate the effect of stream flow on plankton count a partial correlation, holding temperature constant, was made. It was determined that elimination of stream flow increased the variability by only 0.0106 or about one percent. On this basis stream flow may be dropped as a significant variable or by recomputing, using a function of stream flow ($f(X_2)$) other than log (stream flow), significance may be observed. This recomputation was not done.

The correlation between plankton count and stream flow, as tested by both F and t tests was significant at the 10 percent level but not at the five percent level indicating a fair probability than the correlation could have occurred by chance. On this basis it may be reasonably concluded that stream flow was not a significant factor but that temperature was.

<u>Plankton, Temperature, and BOD</u>

The data used in this computation were 10 sets of observations of the two independent variables, temperature and BOD, and the dependent variable, plankton count (Tables 36 - 45). The calculations described above were repeated yielding an equation

$$Y = -6.13 + 5.19 X_1 + 0.50 X_3$$

whereas Y and X_1 are defined as above
and $X_3 = \log \text{BOD (mg/l)}$

and a coefficient of multiple correlation of 0.713. Recalculating the equation for the data on the eight stations used in 1. gave

$$Y = -7.30 + 5.83 X_1 + 0.70 X_3$$

with a coefficient of multiple correlation of 0.752. On the basis of this later coefficient, 57 percent of the variations in plankton are related to variations in temperature and BOD.

As before the coefficient of multiple correlation is significant at the one percent level indicating that the correlation is not attributable to chance.

Discussion

It is obvious from inspection of the data and these calculations that temperature is the major single factor affecting plankton development. Roughly about 50 percent of the variations in plankton count were associated with variations in temperature. Stream flow and BOD were each related to plankton count. Both effects are relatively small. It should be noted that plankton count varies directly with the temperature and BOD and inversely with the stream flow.

These conclusions correspond favorably with those reported in the literature. They differ, however, in that they represent an attempt at a quantitative evaluation of the effect of a physical (temperature), a hydrographic (stream flow), and a chemical (BOD or organic pollution) factor on plankton development. In the Sacramento River from above Spring Creek to below Sacramento River, about 60 percent of the variations in plankton numbers are related to temperature, stream flow, and BOD. Many other factors are undoubtedly involved and most of these have been mentioned. The sharp peak in plankton count downstream from Sacramento has not been explained quantitatively. There is a strong suggestion that

decreased velocity may be responsible. Table 31 shows an average velocity of about 1.7 feet per second at river mile 46.4 as contrasted to an average velocity of about 2.5 feet per second at river mile 90.5 (Table 29). Adequate information is not available to further explore this point. There is also suggestion that the trace nutrient, vitamin B_{12}, may have been involved. The data in Table 15, obtained from bioassays utilizing Lactobacillus leichmannii, are, unfortunately, too scanty to permit detailed evaluation.

Table 15

VITAMIN B_{12} ANALYSES

River Mile	Vitamin B_{12} millimicrograms per liter June 1 - 2, 1961	Vitamin B_{12} millimicrograms per liter June 13 - 15, 1961
297.7		0.002
293.8R (Redding Sewage Treatment Plant Effluent)		0.94
275.0		0.004
242.9R (Red Bluff Sewage Treatment Plant Effluent)		>1.0
217.6		0.005
144.1		0.008
90.5	0.009	0.008
90.2R/0.3 (Colusa Basin Drain)		0.022
81.5		0.013
62.6	0.011	0.014
54.1L (Sacramento Sewage Treatment Plant Effluent)		0.60
52.0		0.013
46.4	0.016	0.016
37.2		0.015
27.4		0.015
18.8	0.017	0.015

Qualitative Aspects

The accumulation of accurate data on kind and number of plankton is difficult. Some of these difficulties have already been described.

In addition to classifying the plankton into the major groups: coccoid and filamentous blue green algae, coccoid and filamentous green algae, pigmented and unpigmented flagellated algae, centric and pennate diatoms, protozoa, rotifers, crustacea, and nematodes, an attempt was made to identify, to genus, the dominant algae and the frequently observed plankters. Data on the distribution of plankton in the major categories is given in Table T-2 at the end of this appendix. The dominant forms are indicated by a code number which is explained at the end of the table. The most common dominating genus was *Synedra* with *Melosira* and *Cyclotella* next in frequency. Thus diatoms were the dominant forms except for a few stations at which the green alga *Ankistrodesmus* was dominant. The dominance of genera or groups will be discussed further.

A summary of the genera of algae identified is shown in Table 16. In this tabulation by genus, and by station, are included 95 genera of algae distribution as follows: blue greens, 15; greens, 38; flagellates, 13; and diatoms, 29. The numbers of genera recovered, by station, irrespective of time or numbers of individuals increased from an upstream low of about 20 to a maximum near 60 and then, in the last few miles of the river decreased slightly. The following genera were recovered at least once from all stations: *Ankistrodesmus*, *Cyclotella*, *Melosira*, *Asterionella*, *Cocconeis*, *Cymbella*, *Fragilaria*, *Synedra*, and *Tabellaria*. All but the first of these are diatoms. Other genera which appeared in at least half of the stations were *Anabaena*, *Lyngbya*, *Oscillatoria*, *Actinastrum*, *Oocystis*, *Pediastrum*, *Scenedesmus*, *Ulothrix*, *Euglena*, *Glenodinium*, *Pandorina*, *Trachelomonas*, *Achnanthes*, *Amphora*, *Ceratoneis*,

Table 16

SACRAMENTO RIVER WATER POLLUTION SURVEY
LIST OF PLANKTON ALGAE*
APRIL 1960 - JUNE 1961

Algae	Station Number 1	2	5	6	7	10	11	12	13	14	15	16	17	19	20	22	23	24	25	26	27	28	Number of Stations at Which Genus Appeared
BLUE GREENS																							
Coccoid																							
Agmenellum (Merismopedia)					x									x	x	x	x	x	x	x	x	x	10
Anacystis (Chroococcus)																	x			x			2
Gomphosphaeria																x		x					2
Filamentous																							
Anabaena		x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
Aphanizomenon								x											x	x			3
Arthrospira															x	x	x	x		x	x		6
Cylindrospermum													x			x							2
Entophysalis (Chamaesiphon)					x																		1
Lyngbya	x		x	x	x	x		x	x	x			x		x			x	x				12
Oscillatoria	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	21
Phormidium		x	x	x	x	x		x									x						7
Plectonema			x																				1
Rivularia		x			x		x	x		x							x					x	7
Spirulina				x	x	x				x	x	x				x				x	x		9
Telypothrix		x																					1
GREENS																							
Coccoid																							
Actinastrum							x				x		x		x	x	x	x	x	x	x	x	11
Ankistrodesmus	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Arthrodesmus																x		x					2
Centritractus type																x							1
Chodatella															x			x	x				3
Closteriopsis						x	x		x	x	x				x		x			x	x	x	10
Closterium														x					x		x		3
Clostridium																x							1
Coelastrum						x									x	x	x	x	x	x	x	x	9
Cosmarium					x			x	x	x	x		x		x	x							8
Crucigenia	x													x	x	x	x	x	x	x	x	x	10
Dictyosphaerium															x				x	x			3
Dimorphococcus															x	x				x		x	4
Elakatothrix																x				x			2
Errerella																				x	x		2
Franceia															x								1
Gloeocystis					x							x											2
Golenkinia															x								1
Kirchneriella						x						x							x				3
Micractinium																x				x	x		3
Nephrocytium																x							1
Oocystis			x	x	x	x	x	x	x	x			x	x		x	x	x	x	x	x	x	17
Ophiocytium								x															1
Pediastrum					x		x	x		x	x	x	x		x	x	x	x	x	x	x	x	15
Pleurotaenium														x									1
Quadrigula															x								1
Scenedesmus	x			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
Selenastrum														x	x	x			x	x	x	x	7
Sphaerocystis type		x												x	x	x		x	x	x	x	x	9
Staurastrum	x		x	x		x	x									x				x	x		8
Tetraedron		x											x		x				x	x	x	x	7
Treubaria																			x		x		2
Cladophora			x	x		x			x		x												5
Mougeotia					x														x				2
Schizomeris type															x								1
Spirogyra			x											x									2
Stigeoclonium	x			x	x	x			x	x													6
Ulothrix	x		x	x	x	x	x	x	x	x		x	x		x		x	x	x				15
FLAGELLATES																							
Pigmented																							
Ceratium	x							x								x		x	x	x			6
Dinobryon									x	x		x	x		x	x	x	x	x	x			10
Dinoflagellate Spore																						x	1
Eudorina type							x									x				x			3
Euglena type			x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	20
Glenodinium type						x	x			x	x			x	x	x		x	x	x	x	x	12
Gonium type				x						x		x		x	x	x		x		x	x	x	10
Mallomonas												x											1
Pandorina			x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	19
Phacus																			x	x			2
Pteromonas																		x		x			2
Strombomonas						x					x	x		x		x	x	x	x	x	x		10
Trachelomonas	x		x	x	x	x	x	x	x		x	x	x	x	x	x	x	x	x	x	x	x	20
U.G.F.[1]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
DIATOMS																							
Centric																							
Cyclotella type[2]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Coscinodiscus[3]																					x	x	2
Melosira	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Pennate																							
Achnanthes			x	x	x	x		x		x	x		x	x	x	x	x	x		x			14
Amphicampa																		x					1
Amphora					x	x				x	x	x	x		x			x	x	x	x		11
Asterionella	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Caloneis type														x									1
Campylodiscus		x				x																	2
Ceratoneis type	x	x	x	x	x	x		x	x	x	x	x	x			x	x	x	x	x	x		18
Cocconeis	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Cymatopleura							x	x			x	x	x	x	x	x	x	x	x	x	x	x	14
Cymbella	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Diatoma type[4]			x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Eunotia type																x							1
Epithemia							x				x	x	x	x	x	x		x	x	x	x	x	12
Fragilaria type	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Frustulia type																		x					1
Gomphonema[4]					x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Gyrosigma[5]			x	x								x	x	x	x	x	x	x	x	x	x	x	13
Meridion type[4]							x														x		2
Navicula type								x		x		x	x	x	x	x	x						9
Nitzschia type[5]	x			x		x	x		x	x	x	x	x	x	x	x	x	x	x	x	x	x	18
Pinnularia type			x			x		x	x		x	x				x		x		x	x	x	11
Rhoicosphenia	x		x		x	x		x	x	x	x	x	x	x	x	x	x		x	x	x		17
Rhopalodia						x		x	x		x	x			x			x			x	x	9
Surirella type										x	x		x		x	x		x		x		x	8
Synedra[7]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Tabellaria type[4]	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	22
Total number of genera per station	22	18	28	28	35	40	29	35	31	36	37	36	37	37	51	56	38	50	48	57	49	41	839

* Algae are listed irrespective of their number or time of appearance.

Footnotes:

1 U.G.F. - Unclassified Unicellular Green Flagellates
2 Cyclotella type includes Cyclotella, Stephanodiscus, Coscinodiscus, of which most forms were about 10_{μ} in diameter.
3 This may have been a morphologically similar but unidentified marine diatom, $20\text{-}50_{\mu}$ in diameter.
4 Under certain conditions some Diatoma could be confused with Tabellaria and Meridion. Under certain conditions some Meridion could be confused with Gomphonema.
5 Gyrosigma type includes all sigmoid forms of characteristic shape such as Pleurosigma.
6 Nitzschia type includes related forms such as Hantzschia and Bacillaria which were rare.
7 Synedra type includes all single long narrow diatoms slightly swollen between poles without apparent true raphe. Size range from 20x3 to $25x10_{\mu}$.

Cymatopleura, *Diatoma*, *Epithemia*, *Gomphonema*, *Gyrosigma*, *Nitzschia*, *Pinnularia*, and *Rhoicosphaenia*.

Relative Distribution of Plankton

The tabular data show strikingly that zooplankton, that is, animal plankton (Protozoa, Rotifers, Crustacea, and Nematodes), represented an insignificant fraction of the total plankton. The percentage of zooplankton was most frequently zero, or when zooplankters were recovered, they averaged less than one percent of the plankton. In only one sample did their proportion approach 10 percent (out of a total of 110 organisms). This low recovery of zooplankters can be attributed to a real reflection of the river flora and fauna, to inadequate laboratory procedures, or both. Recognition and identification, particularly of protozoans, in preserved samples is extremely difficult and this difficulty may be reflected in the low counts observed.

Despite any analytical problems, the results are not inconsistent with the observations of others who found that the zooplankton represented less than 20 percent of the plankton [30, 31, 41]. Kofoid [42] found that the algae were five times as numerous as the zooplankton in the Illinois River. The river data of the Public Health Service National Water Quality Network [43] even more closely resembled these on the Sacramento River.

As has already been indicated, among the algae, and consequently among the total plankton, the single most important group were the diatoms. This is best shown in Figure 19 which is an isometric plot of total diatoms as a percentage of total plankton. The percentage of diatoms ranged from a low of 25 to a high of about 99 with an average of about 75. Figure 20 shows the coccoid green algae as a percent of total plankton.

Figure 19

TOTAL DIATOMS AS PERCENT OF TOTAL PLANKTON

VERTICAL SCALE : EACH SCALE DIVISION = 10 %

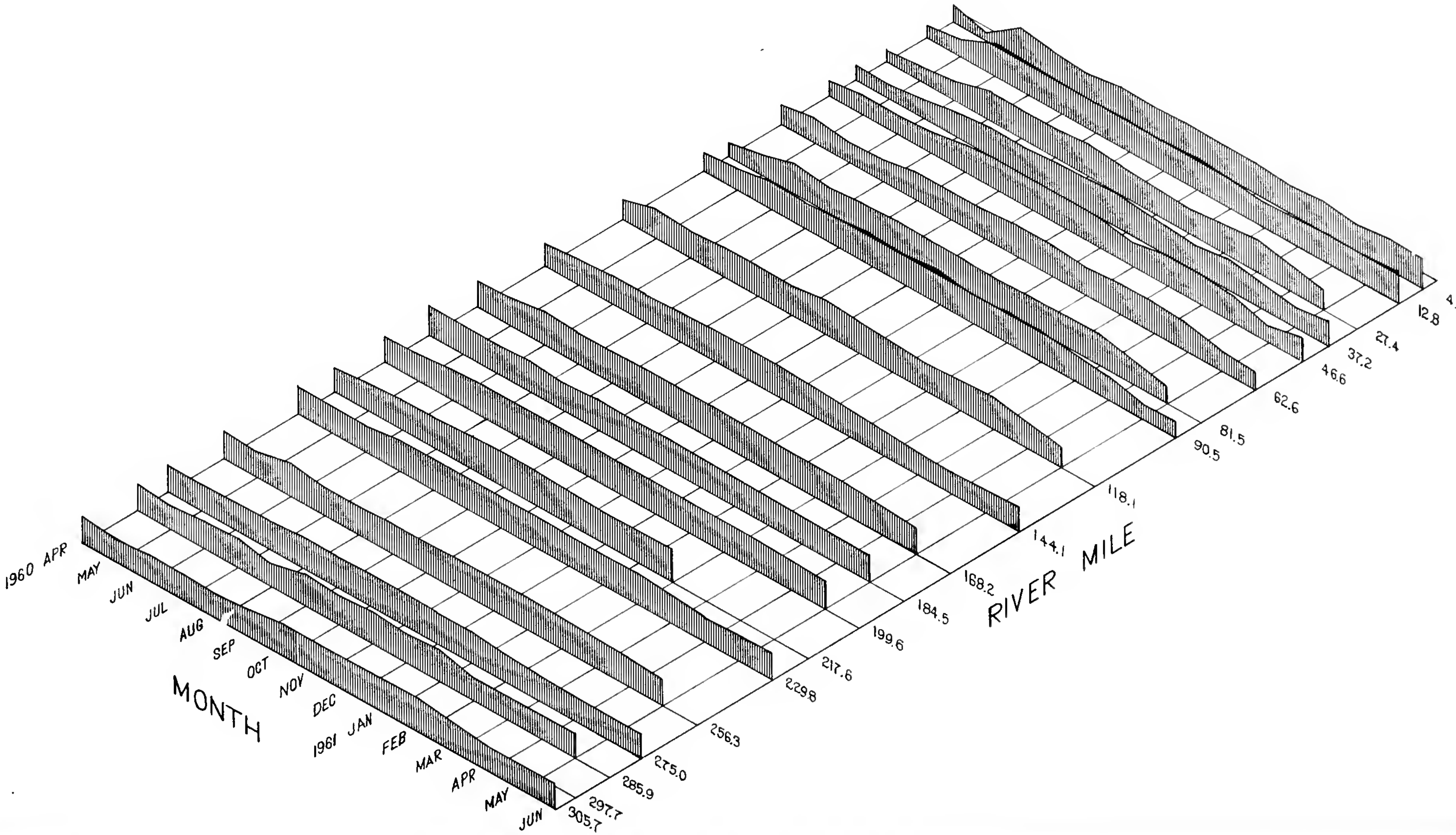
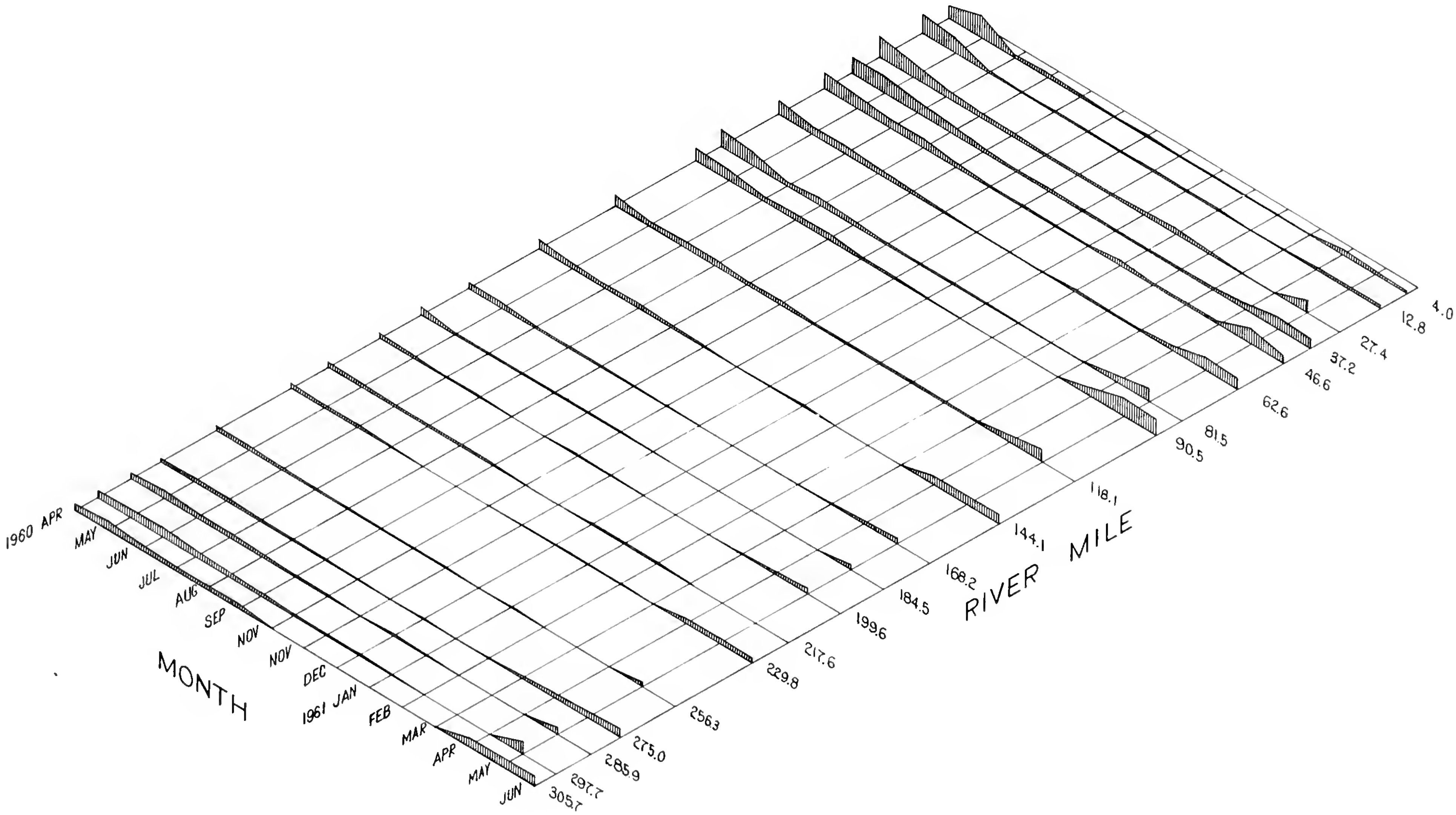


Figure 20

COCCOID GREEN ALGAE AS PERCENT OF TOTAL PLANKTON

VERTICAL SCALE : EACH SCALE DIVISION = 10 %



The coccoid green algae constituted the only group beside the diatoms which were relatively significant. In the Sacramento River, algae other than diatoms, when they appeared in significant numbers, appeared during the warmer months of the year, March or April through September. Also shown is the trend towards higher relative numbers of coccoid green algae as the river proceeds downstream. The maximum percentage of coccoid green algae (64 percent) occurred at the most downstream station in May 1960.

Figures 21 and 22 are isometric plots of the pennate and centric diatoms as percentages of total plankton. The pennate diatoms generally were quantitatively more important than the centric diatoms although variations with time and distance did occur. For example, there is evidence of a slight tendency for maximum numbers of centric diatoms during the winter months and a definite trend towards higher relative (and absolute) numbers of centric diatoms with downstream progress of the river. The maximum percentage of centric diatoms (92 percent) occurred at the most downstream station.

These results are in general agreement with those obtained by others. Kofoid [42] for example found 29 different diatoms and 33 different green algae with about seven times as many individual diatoms as green algae. Allen [27] who studied the San Joaquin River at Stockton also found diatoms to be most numerous. Galtsoff [29] observed that diatoms were dominant in the Mississippi River, comprising, with the blue green algae, 75 percent of the plankton. Melosira was the predominant alga. Similar observations were made by des Cilleuls on the Loire [44], Reinhard on the Mississippi [30], Roach on the Hocking [31], Southern and Gardiner on the Shannon [45], Rice on the Thames [33], and Brinley and Katzin on the Ohio [34]. Coffing [32] on the other hand, found in the White River Canal that the green algae were 2.5 times as numerous

Figure 21

PENNATE DIATOMS AS PERCENT OF TOTAL PLANKTON

VERTICAL SCALE : EACH SCALE DIVISION = 10%

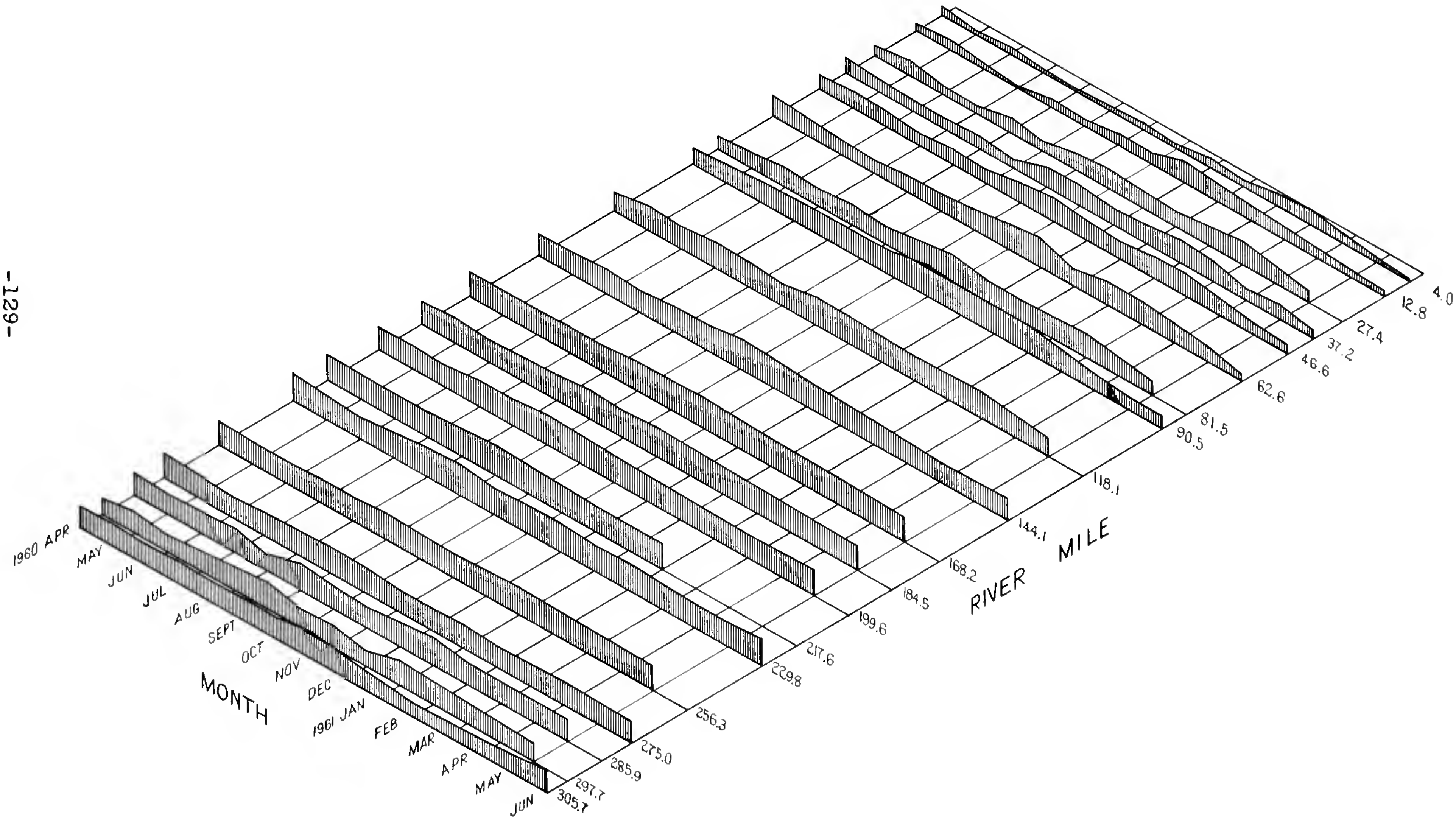
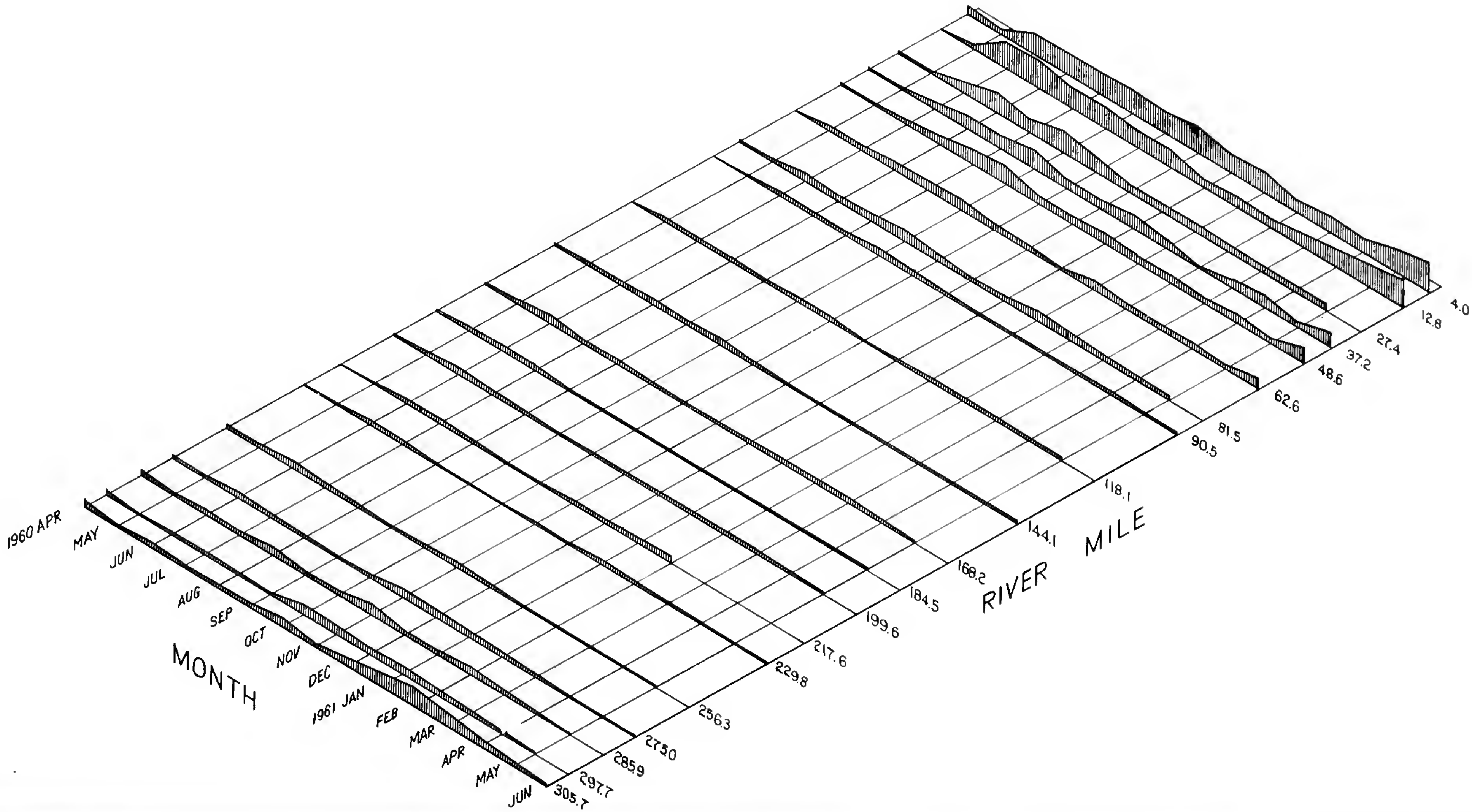


Figure 22
CENTRIC DIATOMS AS PERCENT OF TOTAL PLANKTON

VERTICAL SCALE : EACH SCALE DIVISION = 10%



as the diatoms. She explained this as being due in part to the slow current and low silica content in the canal. Des Cilleuls [46] in his monumental review showed that slow current rivers were characterized by lower diatom contents than rivers with more rapid currents.

Discussion

The typical pattern of plankton distribution in lakes in temperate climates especially is described as follows: there is a large pulse of plankton in the spring, a decreased population in the summer, a smaller but well pronounced pulse in autumn and a minimum population in winter. Diatoms as a whole are most abundant in spring and autumn, blue green algae in late summer and early autumn, and green algae in midsummer. Most river studies have confirmed the occurrence of two peaks in plankton population although the distribution of algae has not necessarily been the same. In the Sacramento River only a single plankton peak in midsummer occurred. Diatoms were predominant at all seasons except that at a number of downstream stations green algae were numerous in midsummer. Blue green and other algae were never relatively numerous.

An explanation for the occurrence of a single plankton peak may be associated with water temperature and diatom temperature optima. Kofoid [26] showed reduced plankton population above 80°F. He also showed that the average water temperature in the Illinois River in July and August was at least 81°F. Galtsoff [29] recorded water temperatures as high as 91°F in July. These high temperatures presumably resulted in decreased plankton growth, but as the temperature decreased, the plankton count again increased. In the Sacramento River observed temperatures never exceeded the apparently critical 80°F, hence produced no decline in plankton number associated with excessive water temperature.

It is difficult to make meaningful comparisons of plankton numbers on different rivers. With the exception of summer peaks and the generally high plankton count at the most downstream stations, the plankton counts correspond well with those observed on other major American rivers (43). If water downstream from Sacramento were to be used for water supplies, difficulties with the plankton could reasonably be expected.

CHAPTER VIII. ORGANIC QUALITY

A tabulation of the results of the organic sample analyses is given in Table 17. Infrared spectra are available for all samples, but have not been included in this report.

The best use of the data obtained in this study will lie in the future when these results can be compared with later analyses, so that changes in the organic quality of the river can be related to changes in discharges of organic pollutants. Present knowledge does not permit a detailed evaluation of the significance of the results included here. Such an evaluation may be possible when there has been more background information accumulated.

The data in Table 16 are reported in groups of broad chemical classes and the results are expressed in parts per billion (ppb). Generally, the chloroform extractables will include the organic material attributable to man made pollutants. A significant exception to this generalization is that the alcohol extract will include synthetic detergents.

Among the fractions that make up the chloroform extract, the neutral group is generally considered of prime importance because it contains groups of compounds that are notorious for taste, odor, and possibly, toxicity.

The ratio of chloroform to alcohol extractable material is a helpful indicator of the type of pollution present. Where industrial pollution is relatively low and domestic sewage is present, the alcohol fraction may exceed the chloroform fraction by a factor of 4 to 6.

It can be seen that the amount of organic material in the river increases roughly three fold from Keswick Dam to Walnut Grove. The level

Table 17

SACRAMENTO RIVER WATER POLLUTION SURVEY
ORGANIC CHEMICALS IN WATER
RECOVERED BY CARBON ADSORPTION METHOD
(Parts Per Billion)

Location	Sample No.	Date	Extractables: Total	Extractables: $CHCl_3$	Extractables: Alcohol	Chloroform ($CHCl_3$) Extractables: Ether Insolubles	Water Solubles	Weak Acids	Strong Acids	Amines	Loss	Neutrals: Total	Neutrals: Aliphatic	Neutrals: Aromatic	Neutrals: Oxy-generated	Neutrals: Loss	Gallons Filtered	Laboratory	Remarks
Sacramento River at Keswick Dam	9	9-26 to 10- 7-60	122	36	86	2	13	2	4	0	10	5	1	1		0	5315	SPH	Water very clear.
	12	11-14 to 11-23-60	137	31	106	0	11	33	3	0	9	5	1	0	4	0	4039	SPH	Water clear.
	16	1-12 to 1-20-61	81	30	51	0	12	3	3	1	5	6	1	0	5	0	5664	SPH	Water clear.
	18	3- 2 to 3- 9-61	106	41	65	8	10	2	4	0	9	8	0	0	6	2	4836	SPH	Water clear.
	22	5- 2 to 5- 8-61	143	37	106	4	10	3	3	1	9	7	0	0	6	1	4125	SPH	Water clear
Sacramento River at Hamilton City	6	8-16 to 8-26-60	98	39	59	0	11	4	3	1	7	13	2	1	10	0	4520	SPH	Water clear.
	13	11-15 to 11-29-60	205	57	148	0	16	6	5	1	17	12	1	0	10	1	4165	SPH	Water slightly turbid.
	24	5-23 to 5-30-61	170	42	128	5	11	5	4	1	7	9	1	0	7	1	4330	SPH	Water slightly turbid.
Sacramento River above Colusa Basin Drain	4	Void																	
	10	10-13 to 10-23-60	238.6	37.6	201	2.4	9.8	5.9	3.4	2.2	1.3	12.6	1.9	0.9	9.5	0.3	4264	TL	Water clear.
	15A	1- 4 to 1-11-61	180.9	26.9	154	0.7	6.7	4.1	1.7	0.9	1.9	10.9	1.4	0.7	8.3	0.5	4100	TL	Water silty.
	15B	1- 4 to 1-11-61	129	35	94	0	14	3	2	1	5	10	1	0	8	1	4233	SPH	Water silty.
	19	4- 5 to 4-12-61	148	55	93	9	13	3	5	1	15	9	1	0	7	1	4476	SPH	Water silty
	27	6-21 to 6-26-61	119	38	81	0	11	2	3	1	10	11	0	1	8	2		SPH	DDT, Dieldrin and DDD indicated present in trace quantities.
Sacramento River at Bryte Laboratory	3	7-12 to 7-26-60	218	70	148	1.7	16	4.2	3.9	0.9	28.7	14.6	1.2	0.7	11.8	0.9	5423	SPH	Water silty.
	7	9- 3 to 9-19-60	Void																
	14	11-12 to 12- 2-60	240	78	162	1	33	8	11	1	5	19	2	1	16	0	3677	SPH	Water very silty.
	17	2-17 to 2-24-61	152	50	102	0	17	4	5	1	13	10	1	1	8	0	4395	SPH	Water turbid.
	20	4-20 to 4-27-61	124	45	79	6	11	3	3	0	12	10	1	0	8	1	4194	SPH	Water silty.
	25	6- 6 to 6-14-61	180	57	123	3	16	4	4	1	18	11	0	0	10	1		SPH	DDT, Dieldrin, DDD indicated present in trace quantities.
Sacramento River at Walnut Grove	11	10-25 to 11-12-60	481	120	361	22.7	27.5	14.3	20.3	5.0	8.8	21.4	3.2	1.3	16.5	0.4	3380	TL	Water silty.
	21	4-29 to 5- 4-61	220	80	140	13	18	6	6	1	20	16	2	1	13	0	3090	SPH	Water silty.
	26	6- 7 to 6-13-61	212	80	132	6	22	6	7	2	20	17	1	1	14	1		SPH	DDT, Dieldrin and DDD indicated present in trace quantities.
El Centro Drain Rice Field - Drain	1	6-24 to 7- 4-60	484	213	271	28	39	13	27	3	70	33	2	1	29	1	5460	SPH	Water clear, herbicide MCPA found = 1 ppb.
Supply	2	7-11 to 7-20-60	257	68	189	7	16	7	7	2	7	22	4	1	17	0	3870	SPH	Water silty.
Colusa Basin Drain	5	8-15 to 8-26-60	280	96	184	2	32	8	10	2	20	21	2	1	19	0	4720	SPH	Water extremely silty.
	8	9- 5 to 9-20-60	233	86	147	1	28	8	8	2	23	16	1	0	14	1	4103	SPH	Water extremely silty.
	23	5-20 to 5-25-61	479	184	295	30	53	18	15	1	36	31	1	3	26	1	2108	SPH	Water extremely silty. DDT about 0.2 ppb. Smaller traces of dieldrin and DDD.

SPH - State Department of Public Health, Division of Laboratories, Sanitation and Radiation Laboratories.
TL - Terminal Testing Laboratories, Incorporated, Los Angeles.

of chloroform extractables which has been associated with taste and odor (200 ppb) is not reached at any point in the river.

The samples collected from the supply and drain of a rice field indicate that there is a significant increase in organic material, particularly in chloroform soluble material, as the water passes through the rice field. The rice field drain sample was collected shortly after the field had been sprayed with the herbicide, MCPA. Application on the field was 12 ounces per acre, estimated to be equivalent to approximately 1 ppm, and 1 ppb of the herbicide was found by ultra-violet spectrophotometry in the drainage water. Samples of the agricultural drainage water from the Colusa Basin Drain had concentrations of organic material comparable to those found in the river near Sacramento. In one sample from the drain, however, 0.3 ppb of DDT and traces of dieldrin and DDD were found utilizing paper chromatographic techniques.

The usual ratio of alcohol to chloroform extractables for all stations fell between 2:1 and 3.5:1 with no particular trend from station to station.

CHAPTER IX. RADIOACTIVITY

Data collected over the past eight years have demonstrated that the radioactivity of the water of the Sacramento River is only slightly above minimum levels detectable with the sensitive equipment and procedures used in the laboratories of the California Office of Civil Defense and Department of Public Health. Because it had been found that the background radiation from natural sources was low, that the use of radioisotopes throughout the watershed was small, that there was no nuclear reactor installation on the watershed, and that atmospheric fallout was low during the river pollution survey, no special radiological samples were collected. Accordingly, data obtained from existing radiological surveillance programs are summarized and presented in this report.

River

Since October 1952, samples for radioassay have been collected twice yearly, usually in May and September, as part of the Statewide Periodic Stream Sampling Program. Assays were made by the Division of Radiological Safety, California Disaster Office.

All of these data are not included here since it had been made available previously by the Office of Civil Defense, but a summary is given in Table 18. It will be noted that on frequent occasions, the results found were so low that they were considered as having no significance. "Suspended" activity is that radioactivity associated with particulate matter of approximately 0.2 microns diameter or larger which is retained by filtration through a membrane filter. "Dissolved" activity is that of the filtrate.

Table 18

RADIOLOGICAL ASSAYS - SACRAMENTO RIVER
BIENNIAL SAMPLES
OCTOBER 1952 - SEPTEMBER 1960, INCLUSIVE

Maximum Radioactivity Found
Micromicrocuries Per Liter

River Station	Number of Samples Collected	Number of Samples Without Significant Activity	Dissolved		Suspended	
			Alpha	Beta	Alpha	Beta
Near Keswick	13	5	10.8 ± 5.4	13.8 ± 6.4	0.9 ± 0.8	24.9 ± 6.9
Near Redding	11	4	6.5 ± 4.6	12.1 ± 7.4	6.8 ± 3.5	9.7 ± 5.8
Near Hamilton City	17	6	9.9 ± 4.1	12.0 ± 9.4	13.7 ± 5.0	14.1 ± 7.9
At Knights Landing	16	8	12.5 ± 3.7	N.S.A.*	7.9 ± 5.0	14.8 ± 7.4
At Sacramento	16	7	6.8 ± 3.7	6.5 ± 5.2	13.0 ± 4.0	9.2 ± 7.3
At Rio Vista	17	7	5.7 ± 4.7	20.2 ± 9.4	11.4 ± 4.5	8.8 ± 7.4

* Samples reported as having no significant activity (N.S.A.) are those samples for which the calculated 90% confidence limits were equal to or greater than the observed activity.

Domestic Water Supply

Both the cities of Redding and Sacramento use treated river water for domestic purposes. Since the spring of 1958, samples of untreated river water have been collected at approximately monthly intervals for radioassay by the Sanitation and Radiation Laboratory, Department of Public Health. Because radioactivity in the samples was so low, the samples were not filtered to distinguish between dissolved and suspended radioactivity, but rather, total (gross alpha and beta) assays are made. No significant alpha activity was found in any of the samples analyzed. The results (beta) are summarized in Table 19 which follows:

Table 19

GROSS BETA RADIOACTIVITY - MUNICIPAL WATER SUPPLY SOURCES
MONTHLY SAMPLES
APRIL 1958 - MARCH 1961

	Number of Samples Collected	Number of Samples without Significant Activity*	Beta Activity Micromicrocuries Per Liter
Redding	26	9	
Maximum Value			20 ± 5
Median Value			3 ± 1
Sacramento	21	3	
Maximum Value			60 ± 4
Median Value			15 ± 3

* Samples reported as having no significant activity (N.S.A.) are those samples for which the calculated 90% confidence limits were equal to or greater than the observed activities.

Fallout

Heavy fallout or "rainout" of nuclear weapon debris was observed statewide early in 1958. At that time the Department of Public Health established a statewide monitoring program to routinely check the levels of radioactivity in soil, food, air, and water. There are two stations on the Sacramento River watershed where air and rainfall are routinely sampled and analyzed. The results of radioassays for rainfall collected at these stations are summarized in Table 20

Table 20

RAINFALL RADIOACTIVITY
REDDING AND SACRAMENTO

Location	Number of Samples	Beta Activity Micromicrocuries per Liter		Total Estimated Rainout Micromicrocuries/sq.ft.
		Maximum	Minimum	
Redding				
1958	11	7890 ± 100	240 ± 8	------
1959	17	4250 ± 30	30 ± 5	42,000
1960	39	70 ± 4	4 ± 1	1,360
1961	29	69 ± 6	6 ± 2	660*
Sacramento				
1958	6	1410 ± 19	200	------
1959	14	2800 ± 20	15 ± 6	24,900
1960	18	125 ± 6	5 ± 2	545**

* Data through April 1961
** Data through May 1960.

Radioactivity in rainfall dropped to very low levels following the cessation of nuclear bomb testing in 1958. During the period of heavy

"rainout" it might have been expected that surface waters would also have been high in radioactivity. There were insufficient samples of Sacramento River water taken at that time to determine if such a result occurred.

Isotope Licensees

A possible source of radiological contamination of the Sacramento River is the disposal of radioisotopes by users situated on the watershed. There are no atomic reactors yet constructed in the basin.

Users of radioisotopes are licensed by the U. S. Atomic Energy Commission. Federal regulations provide that unless a special license is granted, radioactive materials cannot be disposed into a sewer system if the volume of sewage originating on the licensee's premise is not sufficient in itself to dilute the radioisotope to specified levels which are essentially those established for drinking water. Medical users are exempt from this provision. There are no users having special licenses for waste disposal on the watershed.

As of March 31, 1961, there were 18 physicians, veterinarians, industries, hospitals, colleges, or government agencies authorized by the U. S. Atomic Energy Commission to possess unsealed sources of certain radioactive materials in the Sacramento River watershed. Authorization to possess does not necessarily mean usage, nor does it mean that this material, if used, finds its way into the sewers and thence to the river. Licensees are located at Redding, Chico, Orland, Roseville, Woodland, Davis, and Sacramento City and County. The University of California at Davis and the Aerojet General Corporation near Sacramento are relatively large users of radioisotopes.

Raw sewage and sewage sludge samples from the Cities of Sacramento and Redding are now being analyzed on a monthly basis for the statewide

radiological surveillance program of the Department of Public Health. The limited number of samples collected to date have not shown activity significantly above that in the water supply.

In summary, it has been determined that the natural or background radiation of the Sacramento River is low. Rainout from past atomic weapons testing has been the only significant source of activity noted in the river basin. The present use of isotopes on the watershed is not large except for the research activities at the University of California at Davis and at Aerojet General Corporation near Sacramento. There is no evidence that radioisotopes from users are reaching the river in measurable quantities through the sewage treatment plants or through ground water accretions.

CHAPTER X. SUMMARY AND CONCLUSIONS

The study of water quality conditions in the Sacramento River from Shasta Dam to Mayberry Slough extended over a period of approximately fifteen months from the spring of 1960 to the summer of 1961. The purpose of the phase of the study covered in this appendix was to evaluate the public health significance of the present water quality

Bacteriological Quality

1. The bacteriological quality of the Sacramento River above the Redding sewage effluent discharge was good during the June and October sampling periods. The geometric mean densities of coliform bacteria for the two sampling periods were 50/100 ml and 90/100 ml, respectively. (All coliform and fecal coliform bacteria figures given in the summary are geometric mean densities of approximately 30 and 15 samples respectively unless otherwise indicated.)

2. Downstream from Redding and Red Bluff, the bacteriological quality of the river water is adversely affected by the undisinfected sewage discharged from the two cities. The highest coliform bacteria MPN peak values were found in October when the river flow was low: below Redding, 13,500/100 ml and below Red Bluff, 11,100/100 ml. Peak fecal coliform densities in June were 3,600/100 ml and 1,300/100 ml below Redding and Red Bluff, respectively. In all cases the peak coliform bacteria concentrations were found at the first station downstream from the discharges. The fecal coliform bacteria below Red Bluff in June exhibited a nine-hour lag period before reaching peak concentrations.

3. A flow of 0.25 MGD chlorinated primary effluent from the City of Corning was discharged to the river at river mile 217.6 during

the October period. There was no noticeable effect on the river water quality. During the June period, the effluent was confined to land.

4. Agricultural drainage discharges in the middle reach of the river (mile 184.5 - 62.5) caused increases in the coliform bacteria numbers in the river immediately below the drains. No similar increases in the fecal coliform concentrations of the river were observed.

5. The lowest numbers of coliform bacteria in the middle reach were found at river mile 100.2, immediately above the R. D. #108 discharge. Coliform bacteria MPN's/100 ml were 250 and 520 in September 1960, and May 1961, respectively. From this point to mile 62.5 north of Sacramento, the coliform level was increased to 510 and 700 for the two periods. The increase is attributed to five agricultural drains which discharge to the river between these two points.

6. In the lower reach, the coliform bacteria quality is affected by the sewage effluent discharges in the Sacramento area. The West Sacramento Sanitation District discharge, 2 MGD of disinfected primary effluent, had no noticeable effect on the river water bacteriological quality. The City of Sacramento discharges are 40 - 65 MGD of primary effluent which has been given prechlorination and subresidual postchlorination at the main plant and 0.25 MGD of unchlorinated effluent from the Meadowview sewage treatment plant. The coliform bacteria content downstream from these two discharges was 10,800/100 ml to 28,800/100 ml during three sampling periods in June, August - September, and October. The lower peak values occurred when postchlorination at the main plant was increased. The fecal coliform peak content was 2,000/100 ml and 2,800/100 ml during the June and August - September periods. The Meadowview discharge apparently causes a significant portion of the bacteriological concentrations found downstream from both discharges. Any

increase in the bacterial densities of the river that may be caused by waste water from a sugar beet processing plant at Clarksburg is overshadowed by the effects of the upstream discharges. The Isleton and Rio Vista sewage discharges had a local effect on the bacteriological quality of the water in June. No effect was noted in the other sampling periods.

7. The profile of coliform bacteria for June revealed a minor peak at river mile 35 which is 12 miles (10 hours) downstream from the Meadowview sewage discharge. There are no local sewage discharges near mile 35 to account for the peak. The fecal coliform profiles for both June and August-September periods exhibited a major peak at the same point. The peak in the June coliform profile appears to be similar in magnitude to fecal coliform peak for June and may be the result of a so-called "aftergrowth" of fecal coliform bacteria.

8. Investigation of the disappearance rates of coliform and fecal coliform bacteria revealed that the disappearance rates below Red Bluff were extremely low. The rates of disappearance of coliform and fecal coliform bacteria below the Sacramento and Meadowview discharges were consistent for the three sampling programs and the most rapid rate of disappearance was found downstream from Redding during June. In all cases the coliform bacteria exhibited no lag period before the disappearance phase. The fecal coliform exhibited a 9 to 11 hour lag period in most cases.

9. An increase in the postchlorination dosage at the Sacramento sewage treatment plant from 1 ppm to 2 ppm reduced the coliform concentration in the river downstream. The effect of further increases in the postchlorination rate was not readily apparent because of the influence of the nearby Meadowview sewage discharge.

10. The coliform bacteria content of the sewage discharges ranged from 300/100 ml at West Sacramento (pre- and postchlorination) to 39,000,000/100 ml at Redding (no chlorination). The coliform bacteria content of the agricultural drainage water from seven major drains fell within a close range; 1,180/100 ml to 4,600/100 ml.

11. The fecal coliform MPN of the sewage discharges ranged from <180/100 ml and 80/100 ml at the West Sacramento and Isleton sewage treatment plants (chlorination) to 14,300,000/100 ml at the Meadowview sewage treatment plant (no chlorination). The fecal coliform MPN of the agricultural drainage water was 95/100 ml to 330/100 ml.

12. The ratio of fecal coliform to total coliform ranged from 22 - 87 percent and averaged 52 percent for the sewage discharges and ranged from 8 - 13 percent for the agricultural drainage water. A sugar beet process water had 16.6 percent. Log pond water had 10.3 percent. The results indicate that the fecal coliform test does differentiate to a degree between the fecal and non-fecal discharges.

13. There are five domestic water systems that use the Sacramento River as a source of supply. Three of these, Redding Municipal Water System, Rockaway Water System, and the Enterprise Public Utility District System use Sacramento River water above the Redding sewage discharge. The Rockaway system which provides only simple chlorination has exceeded bacteriological limits of the U. S. Public Health Service "Drinking Water Standards". The other two systems that divert water above Redding have met the bacteriological standards. Redding provides chlorination and settling, Enterprise chlorinates water from an infiltration gallery. Sacramento and Vallejo, the other two systems using Sacramento River water, provide complete water treatment and the finished products has consistently met the "Drinking Water Standards".

14. Water-contact sports take place along the entire river with the exception of the immediate Redding area where the water is too cold. Studies have shown that the number of persons engaged in such sports in the area from Anderson to Butte City has doubled in the last four years. On Labor Day weekend, September 2 - 5, 1960, 285 persons were observed engaged in water-contact sports from Butte City to Rio Vista. This was an instantaneous count and the total number of persons over the entire day would have been much larger. In the Sacramento area one of the popular sports areas is at Clay Bank Bend, immediately downstream from the Sacramento sewage discharge. Occasionally detergent foam from the sewage discharge collects along the banks of the river below the discharge and the coliform bacteria concentrations range from 6,000 to 20,000/100 ml. Other popular water-contact sports areas are: Red Bluff, Tehama to Vina, below Hamilton City, mouth of the Feather River, Steamboat Slough, and the Isleton area which are affected to lesser degrees by upstream sewage dischargers.

15. Fecal coliforms may provide a better indicator of determining the suitability of an area for water-contact sports since they are influenced to a lesser degree by non-sewage discharges than are the coliform bacteria.

Chemical and Physical Quality

1. An examination of the chemical quality of the river water showed that the river from Keswick Dam to Rio Vista met all mandatory and recommended limits of the "Drinking Water Standards" for chemical constituents. A minor exception which has little public health significance was the iron-manganese content of the river in the Redding area during storm periods which slightly exceeded the recommended limit.

2. The river water has a negative Langelier "saturation index" indicating that the water will tend to be corrosive and pH adjustment is desirable.

3. Water systems using Sacramento River water have experienced corrosion problems. Redding, Sacramento, and Vallejo have installed lime feed equipment for pH adjustment.

4. The river water may be classified as soft to moderately hard and would not require softening treatment.

5. The greatest effect on turbidity and color is caused by storm flows with turbidities of 350 ppm. During the dry periods the river turbidity in the upper reach is generally less than 10 ppm. Turbidity is increased 10 - 15 ppm by agricultural drainage.

6. Seasonal occurrences of taste and odor in the Sacramento water system are believed to be due to the flushing of creeks that receive industrial wastes and which discharge to the river immediately upstream from the water intake.

7. The influence of bay waters downstream from Rio Vista increases the chloride, sulfate, magnesium, and dissolved solids content of the river. The color and turbidity are also increased in this area.

Plankton

1. Samples analyzed for plankton showed that there was a gradual increase in the total number of plankton as the river progressed downstream. At the Isleton Bridge, about 35 miles downstream from Sacramento, there was a major plankton pulse.

2. Of the chemical physical factors studied, water temperature was the single most important factor affecting plankton development.

In addition to varying directly with temperature, there were less marked variations, directly with BOD and inversely with stream flow.

3. Diatoms of the genera Synedra, Cyclotella, and Melosira were generally the predominating algae. Blue green and other algae were never relatively numerous. Although at some downstream stations green algae, usually Ankistrodesmus, were numerous in mid-summer.

4. If water downstream from Sacramento were to be used for water supplies, difficulty with the plankton could reasonably be expected.

Organic Quality

1. Samples for organic analyses were collected using the carbon adsorption method. General interpretation and evaluation of results of organic analyses have not been fully developed at present. However, in specific instances this technique and the results it yields are of immediate significance.

2. Pesticides when suspected or known to have been applied to fields or crops were recovered quantitatively. Specifically, the herbicide MCPA was found (1 part per billion) in a rice field drain. The Colusa Basin Drain had 0.3 part per billion of DDT and traces of dieldrin and DDD.

3. The analyses of river samples revealed that the average total extractable material increased from 114 parts per billion at Keswick Dam to 350 parts per billion at Walnut Grove. The major increases approximately 170 parts per billion, took place between Sacramento and Walnut Grove.

4. The average chloroform extractable material increased from 35 parts per billion to 100 parts per billion from Keswick Dam to Walnut

Grove. The maximum value at Walnut Grove, 120 parts per billion, is below the value of 200 parts per billion which has been tentatively associated with the presence of tastes and odors in water.

5. The average alcohol extractable material increased from 83 to 250 parts per billion over the same area.

6. The best general use of the data will lie in the future when the present results can be compared with later analyses.

Radioactivity

1. The natural or background level of radiation in the waters of the Sacramento River is low.

2. The levels of radiation found are well below any limits that have been proposed for domestic water supply.

3. There is no evidence that any of the radioisotopes being used by the licensees of the Atomic Energy Commission located throughout the watershed are in any way reaching the river in measurable quantities.

4. Rainout following past atomic weapons tests has been the only significant source of radioactivity found in the Sacramento River Basin.

5. At the present time, the Sacramento River is safe as a source of water supply from the standpoint of radiological quality.

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BASIC DATA TABLES

TABLE T-I

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

1st UPPER REACH INTENSIVE SAMPLING PROGRAM

JUNE 6–10, 1960

MILE 293.9

(1)	(2)	(3)
6/0720	.13	<.018
1020	.045	<.018
1315	.045	
1600	.02	
1920	<.018	
2200	.068	
7/0105	.46	<.018
0345	.068	<.018
0705	.04	<.018
1015	.04	.018
1310	.04	<.018
1605	.02	<.018
1915	.02	<.018
2130	<.018	<.018
8/0055	.11	
0330	.17	
0720	.13	
1010	.17	
1330	.045	
1620	.02	
1930	.045	
2210	.11	
9/0055	.078	.045
0330	.17	<.018
0705	.23	<.018
1010	.02	<.018
1330	<.018	<.018
1630	<.018	<.018
1940	.045	.02
2135	.04	<.018
10/0055	.02	
0345	.02	
0710	.02	

MILE 291.7

(1)	(2)	(3)
6/0820	81	81
1050	23	7.9
1402	4.9	
1650	24	
2020	3.3	
2355	21	21
7/0140	33	1.7
0420	13	1.7
0740	33	1.3
1050	49	3.3
1440	4.6	2.3
1645	18	4.6
1955	11	3.3
2220	7.9	7.9
8/0135	.78	
0410	3.3	
0750	4.9	
1040	18	
1405	4.9	
1650	13	
1948	7.9	
2140	33	
9/0125	3.3	1.7
0420	3.3	1.7
0740	3.3	.78
1045	7.9	2.3
1405	31	13
1655	1.7	1.3
2010	4.9	11
2230	14	4
10/0130	13	
0420	4.9	

MILE 288.3

(1)	(2)	(3)
6/0925	3.3	3.3
1130	46	23
1445	1.7	
1720	17	
2100	4.9	
2320	4.9	1.3
7/0220	4.9	.68
0455	49	3.3
0840	7.9	1.3
1135	11	1.4
1515	7	3.3
1725	23	13
2015	3.3	3.3
2301	13	
8/0215	4.9	
0515	3.3	
0820	7.9	
1125	4.0	
1420	4.9	
1720	7.9	
2020	17	
2320	13	4.9
9/0220	11	7.9
0515	3.3	1.3
0830	7.9	1.3
1125	7	2.6
1435	28	18
1730	4.9	1.7
2035	33	2.4
2325	23	
10/0220	13	
0520	3.3	

MILE 285.9

(1)	(2)	(3)
6/0700	3.3	3.3
1000	7.9	4.9
1300	4.6	
1600	13.	
1830	4.9	
2130	35	
2230	13	
7/0030	11	7.9
0030	4.9	.45
0700	3.1	2.3
1000	3.3	1.3
1240	13	2.3
1555	13	3.3
1835	13	1.4
2130	14	2.3
8/0030	17	
0330	4.6	
0700	4.9	
1000	2.3	
1300	2.3	
1600	.45	
1910	7	
2130	4.9	
9/0030	3.3	2.3
0330	4.9	.45
0700	3.3	.2
1000	3.3	.78
1340	35	7
1600	11	1.7
1900	11	2.6
2130	17	2.2
10/0050	7	
0335	7	

MILE 283.0

(1)	(2)	(3)
6/0750	4.9	2.3
1050	4.9	3.3
1400	1.3	
1630	1.3	
1950	3.3	
7/0130	7.9	3.3
0430	7	.78
0750	7.9	1.1
1050	7	.68
1455	4.9	.68
1700	7.9	2.2
1930	4.9	2.3
2240	7.9	1.4
8/0130	17	
0430	3.3	
0750	3.3	
1050	1.3	
1400	4.9	
1700	4.6	
1740	2.3	
2230	7	
9/0130	7.9	3.3
0430	4.9	.78
0750	2.3	.78
1050	1.7	.45
1410	3.3	2.3
1700	2.2	1.1
1930	4.9	3.3
2230	14	3.2
10/0205	13	
0430	11	

MILE 279.6

(1)	(2)	(3)
6/0820	3.3	.45
1120	4.6	.18
1430	1.7	
1730	.4	
2015	7.9	
2310	4.9	2.3
7/0210	7.9	.23
0510	7	3.3
0820	3.3	1.3
1120	2.3	.45
1430	3.3	1.1
1730	3.3	.78
2000	7.9	.78
2320	3.3	
8/0210	7.9	
0510	3.3	
0820	3.3	
1120	1.3	
1430	2.3	
1730	.45	
2030	3.3	
2310	4.9	.78
9/0210	7.9	2.3
0510	4.6	.78
0820	3.3	1.1
1120	1.3	.2
1445	2.6	1.1
1730	1.7	1.1
2000	3.3	1.7
2310	4.9	
10/0450	7.9	
0510	11	

MILE 275.0

(1)	(2)	(3)
6/0815	13	4.9
1115	4.9	.78
1415	2.2	
1715	.78	
2000	4.6	
2301	1.7	1.3
7/0215	3.3	.78
0510	11	.45
0815	3.3	1.7
1115	2.3	1.3
1420	.78	<.18
1720	1.3	.45
2000	2.2	1.3
2301	3.3	
8/0220	4.9	
0510	2.3	
0815	.68	
1115	2.3	
1425	<.18	
1715	1.3	
2010	1.3	
2301	3.3	3.3
9/0220	13	1.7
0510	7.9	3.3
0815	13	1.3
1115	4.6	1.1
1425	.68	.18
1720	.78	.78
2000	4.9	4.9
2301	7	
10/0215	7.9	
0510	7	

MILE 265.5

(1)	(2)	(3)
6/0855	2.3	1.3
1155	4.9	.45
1505	1.3	
2045	2.2	
2340	2.3	.78
7/0300	3.1	2.3
0550	7	1.7
0855	3.1	.78
1155	7.9	.45
1505	.68	<.18
1800	.2	<.18
2100	1.3	.78
2340	.45	
8/0310	1.3	
0550	2.3	
0855	3.1	
1130	2.3	
1505	.78	
1755	.45	
2050	.78	
2340	1.4	.4
9/0310	2.3	.78
0550	4.9	4.9
0855	3.3	1.1
1155	1.1	.78
1500	.45	.2
1800	.45	.45
2045	2.3	.78
2340	1.1	
10/0310	4.9	
0550	3.3	

MILE 256.3

(1)	(2)	(3)
6/0926	3.3	1.3
1225	7.9	.78
1535	3.3	
1800	.45	
1825	1.1	
2130	.78	
7/0020	.45	<.18
0355	.2	<.18
0620	4.9	3.3
0925	2.3	.78
1225	2.2	.45
1535	2.3	<.18
1830	2.3	.45
2130	<.18	<.18
8/0020	.45	
0355	.78	
0620	.78	
0925	1.3	
1225	4.9	
1535	1.3	
1835	.78	
2125	1.3	
9/0020	.45	<.18
0355	3.3	.45
0550	1.7	.78
0920	2.1	1.1
1225	3.1	.78
1530	.45	.2
1830	1.1	.18
2130	2.3	.78
10/0020	.2	
0620	3.3	
0855	1.3	

MILE 244.1

(1)	(2)	(3)
6/0730	.49	.33
1020	4.5	
1415	1.3	
1640	2.4	
1950	2.4	
2245	1.4	
7/0200	4.9	1.1
0500	3.5	..061
0800	.79	.17
1105	.95	.13
1405	7.9	.23
1650	3.5	.17
1915	.79	.13
2235	.49	.078
8/0040	.46	
0500	.7	
0800	.78	
1100	1.7	
1405	.79	
1650	3.5	
1925	1.1	
2225	.79	
9/0155	.22	<.018
0505	3.5	.17
0800	.49	.078
1110	.49	.33
1400	.49	.23
1700	.49	1.1
1945	1.3	.045
2240	.79	.33
10/0145	1.1	
0505	.49	

MILE 238.1

(1)	(2)	(3)
6/0906	1.7	.4
1145	7	
1450	11	
1715	11	
2015	2.3	
2320	7.9	1.1
7/0238	11	1.7
0525	4.9	1.7
0825	7.9	.61
1140	7.9	1.3
1425	49	2.2
1725	3.3	.45
1945	7	.92
2310	2.3	
8/0215	4.9	
0530	3.3	
0830	3.3	
1145	4.9	
1430	7.9	
1715	2.3	
2020	7.9	
2255	3.3	
9/0230	4.9	1.7
0530	4.9	.4
0845	1.7	1.7
1140	3.1	3.1
1425	4.9	1.1
1725	4.6	1.1
2010	1.4	.4
2305	6.8	
10/0215	4.6	
0530	2.3	

MILE 235.2

(1)	(2)	(3)
6/0945	1.7	.45
1225	4.6	
1525	2.3	
1745	7.9	
2045	11	
2350	3.3	1.7
7/0315	4.9	.45
0600	4	.82
0905	2.3	.45
1210	2.3	4.5
1450	1.7	.78
1750	7.9	7.9
2015	7.9	3.3
2345	2.3	
8/0300	2.3	
0600	1.4	
0915	1.7	
1225	4.9	
1515	7.9	
1740	49	
2045	7.9	
2325	7.9	2.3
9/0310	4.9	3.3
0610	2.3	.78
0930	7	.2
1215	4.9	2.2
1500	2.1	1.3
1750	4.9	.68
2040	3.3	.78
2335	7.9	
10/0300	4.9	
0605	1.7	

MILE 228.4

(1)	(2)	(3)
6/0730	4.9	.68
1045	4.9	
1325	3.3	
1625	1.7	
1910	1.7	
2115	4.9	
7/0115	4.9	1.3
0500	4.9	1.3
0745	7.9	1.7
1045	1.7	.45
1335	1.3	.45
1630	24	1.7
1915	13	1.1
2215	3.3	2.3
8/0115	3.3	
0500	11	
0745	2.3	
1045	2.3	
1330	3.3	
1630	7	
1915	4.6	
2215	3.3	
9/0120	3.3	1.1
0500	7.9	4.9
0750	2.3	.2
1050	2.3	.45
1330	1.1	1.1
1625	7	2.2
1915	7.9	4.9
2215	4.9	4.9
10/0120	13	
0500	7	

MILE 224.4

(1)	(2)	(3)
6/0815	11	3.1
1130	4.6	
1410	1.1	
1700	7.9	
1950	3.3	
2255	14	
7/0200	3.3	1.3
0530	13	1.7
0815	4.9	3.3
1120	1.3	.2
1410	1.3	.2
1700	1.3	.2
1955	4.9	.78
2255	3.3	.45
8/0155	1.3	
0540	4.9	
0815	3.3	
1115	7.9	
1410	.45	
1700	2.3	
1955	3.3	
2255	3.3	
9/0200	11	2.6
0530	7	3.1
0815	4.6	1.4
1120	1.1	.4
1410	.78	.2
1700	3.3	1.3
1955	7	7
2255	1.7	1.7
10/0155	3.3	
0535	2.3	

MILE 217.6

(1)	(2)	(3)
6/0850	4.6	2.3
1205	2.2	
1450	3.3	
1750	1.4	
2050	3.3	
2355	13	.78
7/0300	7.9	1.1
0620	13	.93
0905	7.9	2.2
1220	7.9	.4
1500	1.3	<.18
1755	2.3	.2
2055	4.9	.78
2355	1.3	
8/0250	2.7	
0630	7.9	
0900	3.3	
1200	1.7	
1500	1.3	
1755	.78	
2055	1.7	
2355	2.3	1.3
9/0310	13	<.18
0620	7.9	3.3
0910	1.7	1.7
1205	3.3	.45
1500	1.3	.2
1755	2.1	1.7
2055	1.7	.78
2355	3.3	
10/0300	4.6	
0625	2.7	

MILE 207.1

(1)	(2)	(3)
6/0945	4.6	
1241	2.3	
1540	1.7	
1820	1.7	
2120	.78	
7/0045	13	<.18
0320	13	.4
0615	7	.61
0925	2.3	.45
1240	4.9	.78
1540	1.3	.78
1820	4.9	.45
2120	.78	<.18
8/0030	1.1	
0335	3.3	
0630	3.3	
0930	3.3	
1240	4.9	
1540	3.3	
1820	.78	
2120	3.3	
9/0030	1.4	<.18
0330	2.3	.45
0630	3.3	1.7
0930	2.3	2.3
1240	7	2.1
1540	1.7	1.1
1830	3.3	2.3
2120	.68	.45
10/0030	3.3	
0330	2.2	
0630	1.3	

MILE 199.6

(1)	(2)	(3)
6/0825	3.3	2.3
1143	3.3	
1420	3.3	
1720	4.9	
2010	3.3	
2320	7.9	.2
7/0215	2.3	<.18
0500	3.3	.2
0815	2.3	.45
1130	3.3	<.18
1420	3.3	<.18
1720	1.7	.45
2020	2.3	.78
2320	.68	
8/0230	.78	
0500	2.3	
0815	3.3	
1115	2.3	
1420	2.3	
1720	2.3	
2010	3.3	
2320	1.7	<.18
9/0215	2.1	.4
0515	.78	.2
0815	4.6	.92
1115	3.1	.2
1420	2.7	.4
1720	2.3	1.3
2010	1.4	.92
2320	2.3	
10/0215	3.3	
0515	3.3	
0815	1.7	

MILE 184.5

(1)	(2)	(3)
6/0750	.79	.33
1052	1.1	
1340	1.7	
1640	3.5	
1925	1.1	
2235	2.4	
7/0132	5.4	.46
0425	16	.23
0735	9.2	.33
1045	1.3	.13
1340	1.4	.078
1640	2.4	.14
1925	1.7	.17
2235	5.4	.33
8/0115	2.2	
0435	5.4	
0735	1.3	
1030	3.5	
1340	1.7	
1640	1.3	
1925	3.5	
2235	2.4	
9/0130	5.4	<.018
0430	2.4	.79
0730	2.2	.43
1030	9.2	.17
1340	.31	.045
1640	.79	.79
1925	1.1	.79
2235	2.4	.79
10/0130	5.4	
0430	3.5	
0730	1.3	

REDDING SEWAGE TREATMENT PLANT MILE 293.8R

(1)	(2)	(3)
6/0650	24,000	7,900
1000	11,000	3,300
7/0045	160,000	17,000
0325	92,000	11,000
0650	11,000	7,900
0955	92,000	7,000
1250	160,000	17,000
1540	54,000	7,000
1857	35,000	13,000
2115	35,000	13,000
8/0035	24,000	
0310	35,000	
0650	17,000	
0955	23,000	
1320	11,000	
1605	24,000	
1910	23,000	
2113	33,000	
9/0035	70,000	17,000
0325	79,000	7,900
0655	7,900	2,300
0955	33,000	4,500
1245	95,000	11,000
1610	79,000	49,000
1930	79,000	49,000
2110	49,000	22,000
10/0035	49,000	
0330	49,000	
0700	33,000	

RED BLUFF SEWAGE TREATMENT PLANT MILE 242.9R

(1)	(2)	(3)
6/0730	35,000	7,900
1045	35,000	
1330	35,000	
1615	24,000	
1930	17,000	
2155	17,000	
7/0120	13,000	3,300
0430	7,000	4,600
0630	160,000	35,000
1030	54,000	22,000
1335	35,000	24,000
1620	35,000	24,000
1855	35,000	24,000
2210	17,000	4,900
8/0050	13,000	
0430	35,000	
0725	35,000	
1035	49,000	
1330	23,000	
1625	46,000	
1855	110,000	
2200	49,000	
9/0105	33,000	23,000
0430	13,000	4,900
0720	14,000	7,900
1030	33,000	33,000
1335	49,000	23,000
1630	110,000	23,000
1920	79,000	13,000
2210	33,000	17,000
10/0055	17,000	
0445	33,000	

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.
(3) Fecal coliform bacteria, MPN/100 ml, thousands

TABLE T-I (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

2nd UPPER REACH INTENSIVE SAMPLING PROGRAM

OCTOBER 3-7, 1960

MILE 293.9

(1)	(2)
3/0805	.23
1045	.045
1330	.23
1640	.02
1950	.045
2235	.061
4/0230	.21
0500	.33
0800	.33
1115	.11
1345	.11
1640	.075
1945	.17
2240	.14
5/0215	.23
0520	.093
0805	1.3
1110	.17
1350	.04
1610	<18
1945	.22
2245	.17
6/0220	.33
0510	.17
0800	.045
1110	.49
1345	.33
1645	1.7
1945	16
2250	3.5
7/0230	3.5
0520	16

MILE 291.7

(1)	(2)
3/0850	4.9
1110	33
1400	33
1750	23
2035	22
2310	11
4/0300	7.9
0530	4.9
0845	17
1135	13
1420	17
1710	23
2050	3.3
2310	11
5/0245	3.3
0540	33
0840	79
1140	23
1415	13
1705	13
2015	33
2305	33
6/0245	4.9
0530	23
0820	4.9
1130	17
1410	13
1710	11
2010	14
2310	11
7/0255	49
0530	4.6

MILE 288.3

(1)	(2)
3/0920	7.9
1140	13
1430	17
1810	11
2005	7.9
2340	17
4/0315	7.9
0555	13
0905	33
1155	7.9
1505	28
1735	13
2045	17
2335	23
5/0310	7
0605	4.6
0905	3.3
1159	7.9
1435	7.9
1735	17
2040	13
2335	33
6/0310	13
0600	7
0840	7.9
1155	17
1440	23
1745	13
2035	11
2340	13
7/0315	7
0650	4.9

MILE 285.9

(1)	(2)
3/0810	[illegible]
1110	13
1325	7.9
1635	17
2025	4.9
2240	35
4/0210	13
0450	17
0810	13
1110	11
1350	14
1645	7.9
2000	7.9
2245	13
5/0210	11
0510	13
0810	1.7
1110	17
1400	7.9
1645	11
2000	4.9
2245	11
6/0210	7.9
0510	7.9
0800	4.9
1100	4.9
1355	54
1655	17
1955	13
2245	13
7/0200	7.9
0500	17

MILE 283.0

(1)	(2)
3/0845	3.3
1145	17
1400	4.9
1710	7.9
2100	17
2318	7
4/0245	24
0525	11
0845	13
1145	7.9
1430	7.9
1715	11
2030	54
2315	7.9
5/0245	17
0545	3.1
0845	7
1145	7
1450	7.9
1715	24
2040	54
2225	17
6/0245	13
0545	12
0830	7.9
1130	4.9
1435	3.3
1720	17
2030	54
2315	13
7/0230	7
0530	7.9

MILE 275.0

(1)	(2)
3/0800	4.9
1100	7.9
1400	7
1700	4.6
2005	7.9
2255	35
4/0200	24
0500	35
0800	35
1100	4.9
1355	3.3
1700	3.3
2000	7
2300	7.9
5/0200	2.3
0500	4.9
0800	3.3
1100	3.3
1400	3.3
1700	3.3
1945	7
2300	22
6/0200	22
0500	13
0810	7.9
1100	7
1355	1.7
1700	3.1
1950	4.9
2300	4.9
7/0200	22
0500	13
0800	7

MILE 265.5

(1)	(2)
3/0840	17
1140	3.3
1450	3.3
1735	3.3
2045	4.9
2325	4.9
4/0240	24
0540	7.9
0840	14
1140	4.9
1435	2.3
1740	4.9
2030	3.3
2335	4.9
5/0240	24
0540	24
0840	13
1140	3.3
1435	4.9
1735	4.6
2030	1.7
2335	11
6/0240	24
0840	11
1140	13
1435	4.9
1735	13
2025	3.1
2335	4.9
7/0240	7.9
0540	11
0840	11

MILE 256.3

(1)	(2)
3/0905	11
1210	17
1515	13
1810	4.9
2115	3.1
2355	2.7
4/0310	2.3
0600	7.9
0910	4.9
1210	3.3
1500	2.3
1815	3.3
2050	4.9
5/0005	4.9
0310	7.9
0610	7.9
0900	7.9
1210	7
1500	3.3
1800	7.9
2110	4.9
6/0005	4.6
0310	4.9
0540	11
0610	13
0910	4.9
1210	7.9
1505	7
1800	4.9
2055	4.9
7/0005	13
0310	4.9
0610	7.9
0910	17

MILE 244.1

(1)	(2)
3/0930	1.3
1230	1.7
1515	2.4
1815	5.4
2150	5.4
2400	9.2
4/0040	2.4
0345	3.5
0645	2.4
0945	5.4
1245	5.4
1540	3.5
1845	9.2
2125	16
5/0045	5.4
0345	2.4
0645	3.5
0945	5.4
1245	16
1540	3.3
1830	4.6
2140	1.7
6/0035	3.3
0345	1.7
0645	7.9
1245	4.9
1535	3.3
1835	4.9
2130	13
7/0035	7
0345	4.9
0645	4.9
0945	4.9

MILE 241.8

(1)	(2)
3/1120	<180
1420	<180
1715	<180
2100	<180
2345	<180
4/0210	7.8
0520	18
0800	<18
1100	<1.8
1400	7.8
1645	2
2000	2
2300	7.8
5/0205	13
0515	1.8
0800	4.5
1100	4.5
1400	2
1700	11
2030	22
2300	7.9
6/0210	4.9
0520	4.6
0820	2.3
1110	4.9
1400	17
1650	14
2000	49
2300	33
7/0205	4.9
0515	3.3
0800	9.5

MILE 238.1

(1)	(2)
3/1010	7.9
1300	33
1545	3.3
1845	7.9
2215	13
4/0025	18
0315	7.9
0625	4.9
0900	3.3
1215	23
1500	13
1800	11
2110	7.9
5/0015	11
0315	13
0615	13
1015	4.9
1220	11
1500	17
1815	11
2130	13
6/0015	23
0320	23
0630	17
0925	7
1225	8.4
1250	4.9
1500	33
1800	17
2115	33
7/0010	13
0305	14
0610	13

MILE 235.2

(1)	(2)
3/1030	3.3
1325	33
1615	49
1930	4.9
2245	13
4/0100	7.9
0350	13
0650	14
0930	7.9
1245	4.9
1530	3.3
1830	33
2140	46
5/0045	17
0340	13
0640	4.9
0940	4.9
1245	3.3
1530	11
1845	22
2200	13
6/0045	13
0345	17
0700	3.3
0955	7
1530	17
1830	13
2145	7.9
7/0045	23
0340	23
0635	17

MILE 228.4

(1)	(2)
3/0945	4.9
1240	7.9
1535	1.3
1830	7
2125	13
4/0035	2.3
0340	13
0625	2.3
0935	13
1235	4.9
1535	7.9
1835	13
2135	4.9
5/0030	24
0335	35
0630	7
0950	4.6
1230	3.3
1535	4.9
1835	13
2135	7
6/0030	11
0355	54
0635	4.9
0940	7.9
1240	7.9
1530	3.3
1830	3.3
2135	11
7/0030	24
0340	7.9
0635	11
1010	7.9

MILE 224.4

(1)	(2)
3/0912	11
1505	7.9
1800	2.3
2055	35
2400	3.3
4/0315	7.9
0600	7
0910	17
1210	7
1500	7.9
1805	4.6
2400	4.9
5/0310	24
0610	13
0910	4.9
1210	3.3
1505	17
1805	4.9
2105	3.3
2400	24
6/0325	13
0615	3.3
0915	9.5
1510	13
1800	3.3
2100	4.9
2400	35
7/0315	7
0605	7.9
0920	7.9

MILE 217.6

(1)	(2)
3/0835	13
1130	11
1210	13
1430	3.3
1725	2.2
2025	1.3
2325	7.9
4/0235	7.9
0525	22
0830	11
1130	24
1430	3.3
1730	4.9
2030	3.3
2105	35
2325	4.6
5/0235	35
0540	9.5
0830	14
1130	4.9
1430	3.3
1730	2.3
2030	3.3
2330	7
6/0235	35
0535	4.9
1440	24
1735	4.6
2035	7.9
2330	7.9
7/0235	13
0535	7.9
0825	24

MILE 207.1

(1)	(2)
3/0935	7
1205	3.3
1510	13
1755	7.9
2140	4.6
2350	4.9
4/0245	4.9
0600	3.3
0905	7.9
1200	4.9
1455	3.3
1800	4.9
2110	4.9
5/0010	13
0305	13
0605	24
0910	11
1205	13
1455	24
1750	7.9
2105	3.3
2355	4.6
6/0315	7.9
0600	7
0905	13
1155	24
1500	13
1750	13
2100	7.9
2350	3.3
7/0305	13
0605	7.9
0900	7

MILE 199.6

(1)	(2)
3/0855	3.3
1130	4.9
1430	3.3
1730	4.9
2040	7
2320	4.9
4/0215	3.3
0530	7
0830	7.9
1120	1.7
1425	11
1725	13
2040	4.9
2345	7
5/0240	4.9
0545	54
0845	35
1130	17
1430	13
1725	24
2030	3.3
2315	3.3
6/0235	17
0530	7.9
0835	13
1125	3.3
1425	4.9
1720	7.9
2030	11
2325	13
7/0240	4.9
0530	3.3
0830	14

MILE 184.5

(1)	(2)
3/0800	35
1055	3.5
1355	3.5
1655	9.2
2015	1.7
2250	9.2
4/0145	5.4
0455	9.2
0800	16
1050	2.4
1355	5.4
1650	1.7
2005	1.7
5/0155	3.5
0505	5.4
0800	3.5
1045	1.7
1350	2.3
1650	11
1955	3.3
2245	7.9
6/0200	4.9
0455	7.9
0755	17
1050	9.5
1350	7.9
1650	7.9
2005	7.9
2250	3.1
7/0155	3.3
0505	35
0755	3.1

REDDING SEWAGE TREATMENT PLANT
MILE 293.8R

(1)	(2) Influent	(2) Effluent
3/0745		17,000
1030		46,000
1330		49,000
1625		23,000
2220		79,000
4/0145	13,000	70,000
0440		33,000
0750		13,000
1100		49,000
1325	17,000	49,000
1625		79,000
1930		49,000
2225		33,000
5/0150	46,000	70,000
0445		23,000
0745		49,000
1050		33,000
1330	>2,400,000	33,000
1620		79,000
1930		49,000
2230		23,000
6/0150	33,000	49,000
0445		79,000
0740		23,000
1055		11,000
1330	17,000	23,000
1635		79,000
1930		79,000
2240		33,000
7/0200	17,000	23,000
0440		130,000

RED BLUFF SEWAGE TREATMENT PLANT
MILE 242.9R

(1)	(2) Influent	(2) Effluent
3/0900		49,000
1200		46,000
1445		23,000
1740	13,000	23,000
2115		49,000
2223		33,000
4/0240		22,000
0540	13,000	13,000
0825		22,000
1140	49,000	110,000
1430		33,000
1715	17,000	33,000
2030		79,000
2350		39,000
5/0240		23,000
0540	49,000	33,000
0940		33,000
1130	33,000	33,000
1425		49,000
1730	13,000	23,000
2100		49,000
2330	46,000	17,000
6/0240		23,000
0600	11,000	23,000
0845		17,000
1150	33,000	33,000
1430		110,000
1725	13,000	33,000
2320	46,000	7,900
7/0235		23
0540	3,300	23,000
0830		23,000

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

1st MIDDLE REACH INTENSIVE SAMPLING PROGRAM

SEPTEMBER 12-16, 1960

MILE 184.5

(1)	(2)	(3)
12/0800	3.5	.33
1050	1.3	.33
1400	.49	.078
1710	1.4	.078
2010	3.5	.22
2230	1.1	.21
13/0200	3.5	
0450	16	
0800	1.7	
1100	.79	
1415	1.1	
1710	.33	
2025	2.2	
2305	2.4	.79
14/0155	1.7	1.7
0455	1.3	.79
0755	1.3	.22
1120	.79	.13
1400	1.7	.078
1720	.33	.13
2010	.49	.13
2305	3.5	
15/0150	5.4	
0500	5.4	
0745	2.2	
1120	1.3	
1400	.33	
1710	.46	
2025	.79	
2300	2.4	
16/0510	3.5	1.1

MILE 168.6

(1)	(2)	(3)
12/0920	2.4	.23
1145	1.4	.23
1520	.79	.13
1815	.49	.23
2105	.33	.078
13/0015	.79	
0300	.7	
0545	.46	
0855	2.4	
1225	1.1	
1510	.79	
1805	.79	
2120	.7	
2400	.79	.22
14/0430	.33	.078
0500	.49	.13
0840	.49	.13
1200	1.7	.49
1530	1.3	.49
1815	1.1	.33
2120	.49	.13
2355	.49	
15/0240	1.3	
0555	.49	
0830	3.5	
1220	1.3	
1605	.79	
1800	.46	
2130	.23	
2345	.31	.13
16/0600	1.7	.17

MILE 144.1

(1)	(2)	(3)
12/0850	.49	.078
1225	.7	.045
1510	.17	.078
1740	.27	.02
2130	.22	.018
13/0015	.79	
0305	.46	
0650	.79	
0845	.33	
1145	.33	
1450	.22	
1755	.33	
2050	.17	
2330	.33	.23
14/0250	.33	.13
0530	.33	.045
0840	.23	.13
1150	.23	.02
1445	.13	.045
1745	.49	.078
2040	.79	
2335	.23	
15/0235	1.1	
0540	.31	
0845	.33	
1145	.13	
1445	.33	
1805	.17	
2045	.46	
2355	.79	.068
16/0235	.49	.078
0555	.49	.13

MILE 134.6

(1)	(2)	(3)
12/0810	.23	.23
----	.33	.045
1130	1.3	.078
1475	.33	.17
2020	.49	.02
2340	.46	
13/0208	.33	
0449	.23	
0740	.33	
1110	.33	
1400	.49	
1700	.64	
1925	.33	
2320	1.7	.11
14/0203	.17	.02
0449	.33	.045
0807	.13	.078
1100	.23	.045
1350	.31	.045
1725	.79	.17
2000	.33	.02
15/0155	.95	
0500	1.1	
0740	.33	
1100	.46	
1345	.21	
1715	.27	
2000	.23	
2305	.79	.11
16/0205	.33	.045
0505	.79	.02

MILE 100.2

(1)	(2)	(3)
12/0811	.49	.11
1110	.7	.13
1410	.17	.045
1645	.49	.02
2030	.49	.045
2310	.17	
13/0130	.33	
0530	5.4	
0815	.79	
1050	.23	
1410	.27	
1700	.13	
2010	.23	
2305	.11	.045
14/0230	.078	.045
0515	.078	.045
0750	.46	.31
1045	.46	.23
1350	.17	.018
1655	.13	.02
2005	.23	.02
2305	.13	
15/0215	.23	
0530	.22	
0720	.17	
1100	.17	
1400	.11	
1635	.13	
2010	.092	
2305	.13	.13
16/0245	.061	

MILE 93.7

(1)	(2)	(3)
12/0927	.13	<.018
1230	.34	.045
1450	.49	.045
1730	.46	.045
2130	.26	.02
2400	.17	
13/0230	1.1	
0615	.13	
0850	.49	
1145	2.4	
1450	.49	
1740	.17	
1905	.33	
2400	.46	.068
14/0325	.21	.045
0625	.23	.02
0820	.21	.02
1155	1.7	.27
1445	.49	.068
1730	.11	.02
2100	.078	.078
2345	.23	
15/0310	.49	
0600	.49	
0820	.31	
1145	1.7	
1510	.17	
1710	.26	
1725	5.4	
2055	.13	
2350	.33	
16/0245	.33	
0540	.49	.02

MILE 90.5

(1)	(2)	(3)
12/1011	.46	.045
1343	.33	.045
1610	.46	.02
1615	1.3	.79
2025	.33	.02
13/0110	.17	
0400	.33	
0700	.33	
0945	.13	
1320	1.3	
1600	.33	
1820	.22	
2205	.33	
14/0145	.33	.078
0350	.14	<.018
0720	.068	<.018
0930	.11	.045
1220	.078	<.018
1550	.33	.33
1820	.23	.13
2155	.13	.045
15/0120	.49	
0330	.33	
0700	.26	
0900	.22	
1240	.26	
1545	.23	
1750	.17	
16/0345	1.1	.037
0600	.79	.02

MILE 81.5

(1)	(2)	(3)
12/0830	.49	.078
1215	.17	.11
1400	.49	.045
1700	.46	.23
2000	.49	.02
2330	.33	
13/0210	.79	
0510	.46	
0800	.46	
1110	.79	
1400	.46	
2010	.79	
2320	1.3	.14
14/0210	.33	.23
0515	.22	.04
0800	.13	.11
1100	.22	<.018
1410	.23	.045
1700	.79	.045
2000	.46	
2315	.078	<.018
15/0215	.22	
0530	.17	
0805	.14	
1100	.33	
1400	.22	
1700	.13	
2000	.49	
2320	.17	
16/0220	.49	.078
0510	.79	.078
0715	.17	.078

MILE 77.2

(1)	(2)	(3)
12/0930	1.1	.02
1330	.49	.13
1600	.79	.33
1900	.49	.078
2145	.33	.045
13/0030	1.3	
0315	.22	
0615	.38	
0930	.49	
1250	.33	
1600	.79	
2200	1.1	
14/0045	.33	.23
0330	1.1	.22
0630	.33	.02
0935	1.4	.11
1300	.33	.02
1600	.7	.045
1845	.49	.045
2150	.33	
15/----	.23	.23
0330	.33	
0630	.49	
0930	.22	
1300	.49	
1600	.49	
1900	.22	
2200	2.4	
16/0030	.33	.13
0325	.33	.49
0645	.33	.018
0850	.79	.17

MILE 62.6

(1)	(2)	(3)
12/0800	.13	.045
1120	.49	.23
1400	.31	.23
1700	.46	.045
2000	1.3	.04
2300	1.7	
13/0200	.13	
0500	.49	
0800	.49	
1345	.33	
1620	3.5	
2005	.7	
2300	.7	
14/0200	.49	.068
0500	.33	<.018
0800	1.1	.22
1100	.33	.23
1400	.79	.17
1645	.49	.17
1945	.49	.13
2305	.23	.02
15/0200	.79	.11
0500	.79	
0800	.79	
1100	1.3	
1435	.49	
1630	.21	
1935	.79	
2300	.23	
16/0200	.33	
0500	.49	.093

MILE 58.2

(1)	(2)	(3)
12/0905	.33	.078
1235	1.3	.078
1430	1.8	.068
1735	2.4	.093
2100	1.1	.078
13/0010	1.3	
0305	1.4	
0555	1.1	
0850	.49	
1155	1.7	
1430	.79	
1710	1.7	
2100	1.3	
2355	.7	
14/0310	.49	.11
0550	.79	.018
0850	1.7	.23
1145	.79	.17
1445	5.4	.46
1720	.79	.11
2030	.27	.045
15/0005	.79	.13
0300	.79	.79
0550	1.7	
0855	.64	
1145	1.3	
1500	1.1	
1715	9.2	
2015	.17	
2355	.49	.22
16/0310	.7	.13
0600	.46	.13

BUTTE SLOUGH
MILE 138.9L/0.2

(1)	(2)	(3)
12/0955	1.3	.13
1325	2.2	.23
1615	1.1	.078
1855	1.1	.045
2240	1.1	.078
13/0120	2.2	
0407	2.2	
0645	.95	
0935	1.3	
1250	1.7	
1545	9.2	
1850	.7	
2150	1.7	
14/0035	1.1	.078
0345	2.8	.045
0625	1.7	.078
0930	1.7	.14
1245	.79	.13
1550	2.2	.11
1850	3.5	.14
2145	2.8	.33
15/0030	1.3	
0330	1.2	
0635	1.1	
0955	2.4	
1255	1.1	
1530	1.3	
1910	1.1	
2150	3.1	
16/0050	.7	
0325	.7	.33
0645	1.3	.045

RECLAMATION
DISTRICT NO. 70
MILE 124.2L

(1)	(2)	(3)
12/1505	.26	.13
1805	.33	.17
13/0900	1.7	
1150	1.7	
1455	.49	
1820	1.1	
2050	1.7	
2346	2.2	.17
14/0255	1.7	.23
0530	1.1	.49
0848	.49	.078
1145	3.5	.078
1500	.33	.13
1800	1.3	.23
2105	1.7	.23
2335	2.4	
15/0248	2.2	
0545	16	
0840	5.4	
1150	>24	
1445	>24	
1715	16	
2110	16	
16/0007	22	1.7
0250	16	9.2
0630	9.2	1.1

RECLAMATION
DISTRICT NO. 108
MILE 100.1R

(1)	(2)	(3)
12/0812	1.3	.49
1710	1.3	.49
2100	1.3	.49
2302	2.8	
13/0200	1.7	
0330	.49	
0600	3.5	
1110	1.3	
1425	3.5	
1710	1.4	
2025	.22	
2325	2.2	.17
14/0245	2.8	.14
0535	2.2	.17
0800	1.7	.14
1145	1.4	.49
1415	5.4	.31
1620	2.4	.17
2020	1.7	.46
2320	16	
15/0225	9.2	
0530	5.4	
0730	16	
1120	22	
1415	9.2	
1635	5.4	
2020	4.3	
2315	.7	.078
16/0030	1.7	.093
0230	4	.21
0445	.17	.045
0500	2.2	.14

RECLAMATION
DISTRICT NO. 787
MILE 93.6R

(1)	(2)	(3)
12/0945	5.4	.7
1235	.17	.02
1455	.79	.04
1740	.33	<.018
1815	1.3	.078
2140	.49	.14
13/0015	3.5	
0300	3.5	
0625	3.5	
0900	1.7	
1130	.7	
1500	.79	
1755	1.8	
2120	1.1	
14/0010	1.3	.17
0330	1.7	.11
0640	2.2	.46
0845	2.2	.078
1210	1.4	.078
1455	2.4	.22
1750	5.4	.11
2120	2.2	.23
15/0005	3.5	
0320	.7	
0615	2.2	
0835	1.7	
1200	.7	
1530	.7	
2115	1.1	
2400	1.1	.078
16/0310	1.2	.11
0530	1.4	.02

COLUSA BASIN DRAIN
MILE 90.2R

(1)	(2)	(3)
12/1015	5.4	.33
1349	1.7	.23
1820	.79	.02
2225	.46	
13/0120	3.5	
0410	2.4	
0710	.49	
0955	>24	
1330	.46	
1610	.79	
1830	5.4	
2210	.7	
14/0200	1.1	.23
0400	.79	.093
0730	.79	.13
0950	.46	.46
1230	2.4	.33
1605	3.5	.13
1820	1.3	.23
2205	.7	.22
15/0140	5.4	
0350	1.3	
0710	1.3	
0920	.64	
1250	.49	
1600	.49	
1800	.33	
2150	1.7	
2205	.79	
16/0400	.33	.13
0610	.79	

SACRAMENTO SLOUGH
MILE 80.8L/0.7

(1)	(2)	(3)
12/0845	3.5	.17
1230	2.2	.17
1430	3.5	.27
1730	2.2	.31
2030	1.7	.23
2350	3.5	
13/0225	2.4	
0520	1.3	
0820	2.2	
1140	3.5	
1430	5.4	
2040	1.4	
2345	2.4	.093
14/0240	2.8	.7
0545	1.7	.33
0830	.49	.33
1130	1.2	.092
1430	1.3	.14
1730	1.7	.33
2030	2.4	
2340	1.4	.22
15/0240	1.7	
0550	2.1	
0830	9.2	
1130	1.1	
1430	3.5	
1730	1.7	
2030	4.9	
2345	1.7	
16/0240	17	1.7
0530	.49	
0725	1.5	.79

FEATHER RIVER
MILE 79.9L/0.7

(1)	(2)	(3)
12/0900	.17	.068
1245	.27	.018
1500	.23	.078
1800	.33	.078
2100	.7	.045
13/0005	.79	
0245	.17	
0545	.49	
0945	.49	
1200	.21	
1500	.27	
2115	.22	
14/0015	.17	.018
0300	.22	.13
0600	.49	.045
0900	.27	.02
1200	.23	.045
1500	.17	.02
1800	.17	.02
2100	.46	
15/----	.23	.12
0255	>24	
0610	1.1	
0850	.17	
1200	.22	
1500	.33	
1800	.11	
2100	.79	
2400	.22	.093
16/0300	.33	.045
0605	1.3	.11
0735	.7	.078

NATOMAS MAIN CANAL
MILE 61.5L

(1)	(2)	(3)
12/0920	3.5	.13
1145	16	.7
1435	5.4	1.1
1745	9.2	.33
2050	9.2	.11
2400	5.4	
13/0325	1.1	
0530	.33	
0900	9.2	
1140	16	
1445	.79	
1750	2.2	
2040	2.4	
2400	3.5	.23
14/0300	1.1	.23
0600	5.4	.33
0900	1.7	.33
1215	1.3	.22
1510	2.4	.49
1750	.79	.078
2040	16	.49
15/0015	2.8	.95
0315	2.4	.23
0620	2.8	
0920	7	
1145	1.4	
1445	1.4	
1745	1.4	
2045	1.1	
2400	1.1	.33
16/0300	3.3	2.3
0600	1.4	.078

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.
(3) Fecal coliform bacteria, MPN/100 ml, thousands.

TABLE T-1 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

2nd MIDDLE REACH INTENSIVE SAMPLING PROGRAM

MAY 8-12, 1961

MILE 184.5

(1)	(2)
8/0710	1.3
1125	1.3
1520	2.4
1910	.49
2315	1.3
9/0250	.7
0640	1.1
----	2.4
1455	1.3
1745	.46
2315	1.3
10/0250	1.7
0655	2.3
1225	1.4
1520	.33
1855	.33
2320	.33
11/0255	.95
0655	1.3
1125	.49
1450	.11
1850	.7
2320	1.1
12/0255	.64

MILE 168.6

(1)	(2)
8/0805	1.7
1215	1.3
1610	.49
2005	.49
9/0015	1.3
0350	2.4
0730	.7
1140	1.3
1540	.46
1935	1.7
2400	1.1
10/0350	.49
0805	1.8
1315	1.3
1615	.49
1945	.7
11/0005	1.7
0345	.49
0810	.79
1220	.78
1345	.11
1940	.23
12/0010	1.4
0350	.33

MILE 144.1

(1)	(2)
8/0950	.33
1335	1.5
1715	2.2
2110	2.4
9/0125	.33
0540	1.1
0855	.17
1250	.79
1635	1.3
2040	.49
10/0125	.7
0500	.33
0935	1.7
1405	2.4
1710	.49
2050	.33
11/0105	.95
0450	.46
0910	.79
1330	.49
1655	1.7
2045	.79
12/0115	.17
0505	.17

MILE 134.6

(1)	(2)
8/0835	.13
1250	.33
1645	.17
2030	2.4
2350	.23
9/0400	.4
0755	2.4
1220	.49
1555	.7
2005	.7
2400	1.1
10/0415	1.1
0755	.79
1235	.79
1605	.79
2000	.79
2350	1.1
11/0430	1.1
0830	.49
1250	.49
1605	.7
2130	.7
12/0100	1.3
0355	.33

MILE 100.2

(1)	(2)
8/0855	.21
1250	.22
1655	.23
2105	.26
9/0055	.26
0455	.49
0855	.33
1250	.49
1635	.49
2045	1.7
10/0045	1.3
0455	.79
0855	.17
1240	3.5
1640	.49
2040	.46
11/0055	3.5
0445	.33
0835	5.4
1240	3.5
1640	.79
2040	.33
12/0120	.27
0510	.23

MILE 93.7

(1)	(2)
8/0940	.33
1325	.7
1750	.13
2150	.27
9/0120	.33
0535	.49
0945	1.3
1350	.045
1725	1.3
2130	.33
10/0130	.11
0530	.7
0930	9.2
1330	5.4
1730	1.3
2140	.33
11/0140	.33
0520	1.3
0935	3.5
1330	2.4
1730	.49
2130	.79
12/0205	.33
0550	3.5

MILE 90.5

(1)	(2)
8/1025	.33
1400	1.3
1840	.23
2230	.33
9/0230	.79
0615	.17
1040	.7
1445	.33
1805	.7
2225	.21
10/0210	.49
0610	.49
1010	2.4
1420	3.5
1820	1.1
2220	.79
11/0215	.33
0610	2.4
1015	1.3
1410	9.2
1810	1.3
2200	.22
12/0255	.33
0620	.31

MILE 81.5

(1)	(2)
8/0835	.33
1320	.17
1700	.13
2045	.23
9/0035	.79
0450	.21
0935	.79
1330	2.4
1720	.79
2115	3.5
10/0030	.14
0438	.22
0853	.49
1245	.68
1640	2.8
2100	4.9
11/0033	.33
0433	.13
0824	1.1
1240	1.3
1720	.78
2105	1.1
12/0055	.46
0505	3.5

MILE 79.0

(1)	(2)
8/0942	.33
1410	1.1
1725	2.4
2140	.49
9/0125	.26
0522	.49
1025	5.4
1400	5.4
1805	.49
2150	3.5
10/0120	1.3
0520	.33
0930	.14
1315	.7
1720	2.4
2135	1.3
11/0115	.79
0509	1.3
0910	.33
1325	2.4
1805	1.8
2145	.31
12/0153	1.3
0540	2.4

MILE 71.0

(1)	(2)
8/0800	.17
1200	.22
1600	.46
2030	.26
2400	.32
9/0400	3.5
0800	.22
1200	1.3
1540	1.7
2000	1.7
2400	.31
10/0400	.33
0800	.33
1200	3.5
1600	1.1
1955	.79
2400	.79
11/0400	3.5
0750	3.5
1200	1.3
1600	.34
2000	.95
12/0020	1.1
0420	.34

MILE 62.6

(1)	(2)
8/1047	.33
1520	.33
1718	.33
1900	.33
2300	.33
9/0310	.46
0640	.79
1130	2.4
1525	1.1
1930	.79
2245	.22
10/0222	.46
0638	.6
1112	.23
1515	.78
1900	7.9
2250	1.1
11/0215	1.7
0608	.49
1030	.7
1540	.93
2005	.78
2310	3.5
12/0323	.46
0710	1.3

BUTTE SLOUGH MILE 138.9L/0.2

(1)	(2)
8/0745	1.3
1145	2.4
1525	1.3
1930	.64
2330	.79
5/0340	.79
0730	.33
1140	2.4
1525	2.3
1930	2.8
2340	.95
10/0350	.7
0730	1.4
1135	1.7
1530	7.9
1930	17
2330	.79
11/0410	.33
0745	1.4
1210	11
1530	2.4
1920	.49
12/0040	.79
0330	.79

RECLAMATION DISTRICT NO. 70 MILE 124.2L

(1)	(2)
8/0925	3.5
1340	1.7
1725	2.4
2115	2.4
9/0015	.49
0420	1.7
0825	.49
1250	.79
1625	2.3
2030	3.3
10/0030	1.7
0440	.49
0820	2.7
1240	1.7
1640	2.2
2025	9.5
11/0020	1.1
0455	2.2
0910	.7
1315	4.9
1630	3.5
2055	17
12/0125	.7
0425	.79

RECLAMATION DISTRICT NO. 108 MILE 100.1R

(1)	(2)
8/0915	.33
1305	3.5
1720	3.5
2120	1.7
9/0115	.79
0515	2.4
0915	1.3
1300	.33
1645	3.5
2055	1.7
10/0100	2.2
0505	1.7
0905	.56
1250	16
1650	3.5
2050	3.5
11/0105	2.4
0455	>24
0845	5.4
1255	9.2
1650	3.5
2050	3.5
12/0135	9.2
0530	16

RECLAMATION DISTRICT NO. 787 MILE 93.6R

(1)	(2)
8/0955	1.4
1335	1.3
2205	2.2
9/0155	3.5
0550	3.5
0955	3.5
1735	7.9
10/0140	2.6
0940	13
1340	54
1740	92
2150	4.9
11/0535	7.9
1345	.79
1740	9.5
12/0225	1.8

COLUSA BASIN DRAIN MILE 90.2R/0.3

(1)	(2)
8/1035	.33
1405	9.2
1845	3.5
2235	.23
9/0210	1.3
0620	3.5
1050	16
1450	1.8
1810	3.3
2130	11
10/0220	.79
0615	.79
1015	.78
1425	1.7
1825	3.3
2230	3.3
11/0225	1.1
0615	35
1025	13
1420	13
1820	5.4
2210	.79
12/0305	1.3
0640	1.7

SACRAMENTO SLOUGH MILE 80.8L/0.7

(1)	(2)
8/0852	1.1
1330	.33
1710	2.4
2100	1.1
9/0055	1.4
0500	1.1
0952	1.1
1340	16
1745	.49
2125	9.2
10/0045	7
0450	1.7
0901	1.3
1255	7.9
1645	3.5
2115	11
11/0050	7
0445	.22
0839	1.3
1255	1.4
1735	.79
2120	1.4
12/0115	2.2
0517	2.2

FEATHER RIVER MILE 79.9L/0.7

(1)	(2)
8/0915	.49
1350	.22
2125	.46
9/0110	.49
0510	.27
1002	.79
1350	1.3
1755	.79
2140	.27
10/0110	.49
0502	.31
0912	.33
1305	.23
1700	.33
2125	.49
11/0102	1.4
0457	.49
0853	5.4
1310	2.2
1755	.13
2135	1.7
12/0135	1.7
0528	.49

RECLAMATION DISTRICT NO. 1000 MILE 61.5L

(1)	(2)
8/1820	1.3
2230	3.5
9/0215	1.7
0600	1.1
1100	3.5
11/1500	4.6
1925	7
2240	11
12/0435	17
0628	35

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.

TABLE T-1 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

1st LOWER REACH INTENSIVE SAMPLING PROGRAM

JUNE 20-24, 1960

MILE 62.6

(1)	(2)	(3)
20/0815	.79	.17
1107	.49	.02
1412	.79	.045
1700	1.3	.045
2027	.33	.02
2300	.22	
21/0202	.7	
0459	1.7	
0800	.46	
1110	.49	
1405	3.1	
1706	.46	
2016	.23	
2301	.22	.33
22/0201	1.1	.17
0502	.79	.02
0800	.22	.04
1107	1.3	.13
1412	.79	<.18
1713	.26	.068
2017	1.1	.04
2302	.22	
23/0202	.7	
0502	.27	
0802	.17	
1118	.79	
1412	3.1	
1702	.31	
2006	.27	
2302	1.3	.23
24/0202	.7	.045
0202	.49	<.018

MILE 58.2

(1)	(2)	(3)
20/0850	1.8	<1.8
1129	2	<1.8
1435	.45	<.18
1730	.45	<.18
2053	.2	<.18
2340	.78	
21/0230	1.3	
0522	.023	
0830	.78	
1136	1.3	
1430	1.1	
1727	.68	
2043	.27	
2330	.49	.078
22/0230	.79	.045
0525	.17	<.018
0826	.79	.018
1131	.27	.045
1435	2.2	.078
1732	.7	.02
2048	3.3	.04
2331	2.3	
23/0232	3.3	
0537	7	
0832	3.3	
1139	1.7	
1433	.17	
1726	3.3	
2030	2.3	
2330	3.3	.02
24/0232	1.3	.12
0521	1.7	.33

MILE 54.2

(1)	(2)	(3)
20/0920	2	<1.8
1211	4.5	4.5
1504	1.1	.2
1800	.45	<.18
2124	1.3	<.18
2315	.45	
21/0301	.45	
0604	1.3	
0909	.2	
1203	.78	
1457	.68	
1755	.45	
2113	.33	
22/0012	.49	.045
0306	.33	.17
0609	.7	.21
0909	.17	.045
1156	.33	.045
1501	1.3	.045
1757	.79	.045
2122	2.2	.11
23/0011	3.3	
0300	1.7	
0602	.79	
0909	1.3	
1201	3.3	
1459	.49	
1750	.79	
2058	1.1	
24/0009	1.3	.11
0310	1.3	.11
0609	.79	.13

MILE 50.8

(1)	(2)	(3)
20/1211	130	4
1505	49	11
1752	240	7.8
2028	920	
21/0052	79	
0315	130	
0600	350	
0900	7.9	
1142	46	
1500	12	
1740	7.8	
2117	4.5	
22/0009	2	<1.8
0345	4.5	2
0700	9.3	<1.8
1139	49	<1.8
1459	17	<1.8
1847	7.8	<1.8
2031	4.5	<.018
23/0005	7.8	
0405	13	
0610	49	
0900	23	
1126	13	
1443	11	
1803	7.8	
2045	6.8	
24/2350	4.5	<1.8
24/0310	2	<1.8
0600	46	13
0855	49	7.8

MILE 46.2

(1)	(2)	(3)
20/----	130	49
0955	350	7.9
1231	13	2.2
1545	46	1.3
1824	23	2
21/0045	49	
0355	350	
0630	49	
0955	540	
1215	110	
1532	49	
1814	33	
2155	33	
22/0052	23	2
0415	2	<1.8
0800	70	20
1207	230	33
1529	17	2
1904	6.8	<1.8
2102	7.8	<1.8
2145	11	<1.8
23/0110	7.8	
0435	17	
0630	33	
0926	230	
1156	49	
1506	13	
1837	13	
2120	13	
24/0036	14	2
0345	13	<1.8
0626	13	<1.8
0921	1.7	<1.8

MILE 43.4

(1)	(2)	(3)
20/1045	13	3.3
1248	21	11
1600	22	.78
1843	4.9	1.1
2159	350	
21/0115	17	
0415	130	
0740	240	
1010	33	
1234	110	
1551	79	
1834	46	
2247	7.8	
22/0118	7.8	<1.8
0430	7.8	<1.8
0950	23	<1.8
1233	23	2
1547	46	2
1916	33	<1.8
23/0105	46	
0445	7.8	
0645	17	
0940	17	
1208	4.5	
1520	33	
1907	17	
2150	4.5	
24/0100	2	2
0405	13	<1.8
0645	2	<1.8
0940	11	2

MILE 39.8

(1)	(2)	(3)
20/1041	13	.45
1311	7.8	<1.8
1623	17	2
1902	2	2
2234	7.8	2
21/0135	7.8	17
0435	7.8	
0715	33	
1040	23	
1256	33	
1618	27	
1904	4.5	
2249	11	
22/0200	13	<1.8
0455	6.8	2
1010	33	<1.8
1252	17	<1.8
1610	1.8	<1.8
1932	14	2
2224	23	<1.8
23/0220	7.8	
0500	2	
0710	17	
1000	2	
1240	6.1	
1550	7.8	
1929	13	
2222	23	
24/0135	11	<1.8
0430	2	<1.8
0713	6.1	<1.8
1010	6.8	4.5

MILE 37.2

(1)	(2)	(3)
20/0929	17	4.9
1230	49	2.2
1509	3.3	2.3
1816	13	3.3
2039	7	3.3
2337	2.3	
21/0305	3.3	
0620	7.9	
2122	49	
2400	230	7.8
22/0308	23	7.8
0537	13	2
0855	23	2
1127	14	<1.8
1500	7.8	<1.8
1733	6.8	<1.8
2110	13	<1.8
23/0325	33	
0541	13	
0908	11	
1158	13	
1512	2	
1741	9.3	
2039	7.8	
2351	7.8	<1.8
24/0311	170	4.5
0631	3.3	2
0901	7.8	<1.8

MILE 34.4

(1)	(2)	(3)
20/0947	7.9	2.3
1250	23	4.9
1521	23	1.7
1833	13	1.7
2117	4.9	1.1
2352	7.9	
21/0326	6.4	
0645	7	
2144	49	
22/0025	23	<1.8
0325	13	7.8
0558	13	2
0916	11	4
1141	13	<1.8
1513	13	2
1745	1.8	<1.8
2138	7.8	1.8
23/0346	17	
0600	11	
0924	6.8	
1219	4.5	
1528	13	
1754	2	
2107	7.8	
24/0013	23	4.5
0330	6.8	2
0646	130	<18
0919	13	2

MILE 32.5

(1)	(2)	(3)
20/1002	33	4.6
1304	13	4.9
1540	17	1.1
1850	4.9	.78
2134	7.9	.78
21/0014	3.3	
0342	4.9	
0655	23	
2203	7.9	
22/0041	17	1.3
0342	11	.45
0614	14	2.3
0932	130	<1.8
1152	11	1.3
1532	2.6	.78
1756	7	.45
2157	17	.4
23/0410	1.7	
0614	4.9	
0942	4.9	
1236	7	
1541	9.5	
1808	1.7	
2126	3.3	
24/0027	7	.4
0345	4.2	.72
0656	3.3	.2
0945	4.9	.45

MILE 30.1

(1)	(2)	(3)
20/1017	5.4	.33
1321	>2.4	1.1
1556	2.4	.79
1903	>24	9.2
2151	9.2	.49
21/0033	16	
0401	16	
0710	3.5	
2220	11	
22/0058	4.6	.78
0400	7.9	.4
0633	7.9	.93
0951	6.4	1.4
1207	13	3.3
1544	4.6	.4
1807	3.3	.45
23/0420	.78	
0628	4.9	
1000	4.9	
1252	11	
1555	1.7	
1823	2.3	
2145	7.9	
24/0044	.2	<.18
0400	2.3	.45
0705	2.2	<.18
1000	3.3	.2

MILE 27.4

(1)	(2)	(3)
20/0750	3.5	.79
1045	16	1.8
1120	16	2.4
1400	5.4	.49
1650	5.4	2.4
1955	5.4	2.4
21/0155	2.4	
0445	5.4	
0815	2.4	
1055	3.5	
1350	7	
1650	7	
2000	1.3	
2300	2.2	
22/0230	2.3	.2
0610	11	.18
0840	7.9	<.18
1110	3.3	<.18
1350	1.7	
1556	7.9	
1819	13	.2
23/0441	1.3	
0643	1.3	
1014	1.3	
1317	4.9	
1625	2.1	
1839	17	
2203	3.3	
24/0102	1.7	<.18
0418	1.3	.2
0716	3.3	.45
1014	1.7	.45

MILE 25.5

(1)	(2)	(3)
20/0815	9.2	2.4
1135	3.5	.23
1420	1.1	.33
1710	1.4	.23
2020	5.4	.7
2310	2.8	
21/0215	1.7	
0505	2.2	
0830	1.1	
1115	5.4	
1410	1.3	
1710	7.9	
2020	13	
2320	3.3	.45
22/0300	.78	<.18
0620	.93	.2
0855	13	7.9
1130	1.3	.2
1410	1.3	<.18
1710	2.3	.2
2000	4.9	.45
2320	4.6	
23/0210	4.9	
0505	1.1	
0805	2.1	
1110	4.9	
1410	1.4	
1710	.78	
2010	.78	
2305	3.3	.78
24/0205	2.3	.68
0525	.2	<.18

MILE 23.3

(1)	(2)	(3)
20/0900	5.4	.46
1200	2.8	.46
1440	.79	.49
1730	.79	.23
2040	1.7	1.1
2350	1.7	
21/0240	1.7	
0525	1.7	
0850	5.4	
1135	1.7	
1430	1.7	
1730	.78	
2040	2.2	
2350	.4	<.18
22/0340	.61	.4
0640	.93	.61
0915	24	<.18
1145	2.3	<.18
1430	3.3	.2
1730	1.3	.2
2040	7.9	.68
2345	4.9	
23/0235	4.6	
0525	1.3	
0825	1.1	
1135	1.7	
1435	.2	
1735	.78	
2035	2.3	
2330	2.3	1.3
24/0230	1.3	
0550	2.3	.18

MILE 21.1

(1)	(2)	(3)
20/0915	2.4	.79
1220	1.1	.23
1500	1.7	.13
1750	1.3	.17
2100	2.4	.22
21/0020	.49	
0305	.79	
0540	2.4	
0910	1.7	
1155	1.7	
1450	3.1	
1750	.79	
2100	2.3	
22/0015	1.7	.17
0410	.49	.17
0700	.49	.23
0930	.23	.23
1200	.79	.33
1455	3.3	.11
1750	.33	.04
2100	3.3	.68
23/0005	1.3	
0300	.31	
0545	1.3	
0840	1.1	
1155	.79	
1455	2.3	
1745	.79	
2055	1.3	
2350	.23	.078
24/0255	1.1	.17
0610	.33	.13

MILE 18.8

(1)	(2)	(3)
20/0935	.33	.078
1240	.49	<.018
1515	.22	.068
1810	2.4	.33
2120	3.5	.23
21/0040	1.3	
0330	1.7	
0645	2.4	
0925	1.7	
1215	1.3	
1510	2.2	
1810	1.1	
2120	.33	
22/0040	.79	.23
0715	.33	.23
0945	.49	.23
1215	1.1	.13
1515	1.1	.04
1810	2.4	
2110	.49	.068
23/0030	.23	
0320	1.7	
0605	.49	
0900	1.4	
1215	.95	
1515	1.1	
1815	.79	
2115	.49	
24/0010	.33	.068
0320	1.1	.02
0635	.49	.13

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.
(3) Fecal coliform bacteria, MPN/100 ml, thousands.

TABLE T-1 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

1st LOWER REACH INTENSIVE SAMPLING PROGRAM

JUNE 20-24, 1960

(Continued)

MILE 15.1

(1)	(2)	(3)
20/0730	49	.2
1030	11	.2
1330	1.1	<.18
1630	.2	<.18
1930	3.3	.2
2230	1.1	<.18
21/0800	3.3	
1030	4.3	
1330	2.2	
1630	.2	
1930	17	
2235	4.9	
22/0240	1.7	.2
0455	1.4	<.18
0735	2.1	1.4
1030	13	2.3
1330	.78	<.18
1630	2.1	.2
1930	2.1	.61
2235	1.4	.93
23/0150	2.2	
0440	1.7	
0755	.45	
1030	.93	
1330	.2	
1630	2.1	
1930	.83	
2235	.45	

MILE 13.4

(1)	(2)	(3)
20/0740	4.6	.2
1040	1.4	<.18
1340	.78	<.18
1640	3.1	.18
1940	1.1	<.18
2250	4	1.1
21/0810	2.7	
1040	.78	
1340	.7	
1640	2.2	
1940	1.3	
2250	1.7	
22/0215	3.3	.46
0505	.16	<.018
0740	1.3	.045
1040	2.3	<.18
1340	2.2	.078
1640	24	1.3
1940	.49	.02
2255	7.9	.078
23/0210	7.9	
0450	4.9	
0800	.33	
1040	.21	
1340	1.4	
1640	1.3	
1940	2.3	
2300	1.1	

MILE 9.5

(1)	(2)	(3)
20/0802	4.9	<.18
1102	1.3	.2
1402	1.3	.2
1702	1.7	.45
2002	3.3	.45
2315	2.1	
21/0825	22	
1102	2.2	
1402	.31	
1702	.79	
2002	2.2	
2328	.24	<.018
22/0235	7.9	.68
0525	.33	.068
0800	3.3	.79
1102	1.1	.7
1402	3.3	.2
1702	1.3	.13
2002	3.3	.17
2325	.7	
23/0235	1.7	
0510	1.3	
0815	.22	
1102	35	
1402	3.3	
1702	.79	
2002	.79	

MILE 4.0

(1)	(2)	(3)
20/0834	<.18	<.18
1134	.78	<.18
1434	.45	.2
1734	.45	.2
2034	.2	<.18
21/0845	.2	
1134	.68	
1434	.79	
1734	3.3	
2034	.7	
22/0020	.49	.11
0300	.33	.13
0545	.33	<.018
0820	.23	.078
1134	.23	.045
1434	2.2	.21
1734	1.3	.2
2034	.49	.078
23/0010	.33	
0300	1.7	
0535	.46	
0835	.33	
1134	.49	
1434	.23	
1734	2.3	
2034	.33	

NATOMAS EAST MAIN DRAIN
MILE 60.6L

(1)	(2)	(3)
20/1045	200	<180
1700	180	<180
2240	450	200
21/0450	46	
1045	110	
1640	6.4	
2255	110	
22/0445	49	1.4
1050	22	2.2
1645	49	.45
2245	79	4.5
23/1045	7.9	
1640	22	
2245	79	
24/0445	49	.68

AMERICAN RIVER
MILE 60.4L

(1)	(2)	(3)
20/1015	2.3	<.18
1630	.78	<.18
2215	1.3	<.18
21/0425	1.3	
1015	3.3	
1615	1.3	
2215	.49	
22/0415	3.3	.11
1025	.79	.02
1615	3.3	<.18
2215	7.9	<.18
23/0440	3.3	
1020	2.3	
1615	1.7	
2215	2.3	
24/0415	3.3	.17

WEST SACRAMENTO SEWAGE
TREATMENT PLANT
MILE 58.0R

(1)	(2)	(3)
20/1130	<180	<180
1730	<180	<180
2315	<180	<180
21/0520	<180	
1115	<.18	
1715	.45	
2325	.2	<.18
22/1115	.2	<.18
1720	.18	<.18
2315	140	
23/1115	<.18	
1715	.78	
2315	<.18	<.18
24/0515	.2	.18

SACRAMENTO SEWAGE
TREATMENT PLANT
MILE 54.1L

(1)	(2)	(3)
20/1555	2,300	180
2140	11,000	3,300
21/0945	3,300	
1540	140	
2140	200	
22/0915	1,600	33
1540	.2	<.18
2140	17,000	680
23/0940	<180	
1540	7.8	
2140	1,100	

ISLETON SEWAGE TREATMENT PLANT
MILE 18.1L

(1)	(2)	(3)
21/1500	22,000	
1500	24,000	
23/1500	4.5	
1500	6.8	

RIO VISTA SEWAGE
TREATMENT PLANT
MILE 11.6R

(1)	(2)	(3)
21/1525	24,000	
1525	11,000	
23/1530	4,900	
1530	14,000	

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.
(3) Fecal coliform bacteria, MPN/100 ml, thousands.

TABLE T-1 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

2nd LOWER REACH INTENSIVE SAMPLING PROGRAM

AUGUST 29-SEPTEMBER 2, 1960

MILE 62.6

(1)	(2)	(3)
29/1023	24	
1300	.33	
1623	.7	
1933	.33	
2223	.79	
30/0123	3.5	.26
0423	.23	.13
0703	.46	.045
1020	1.7	.17
1323	.79	.14
1623	.22	.045
1923	.49	.23
2223	3.5	.7
31/0117	1.4	
0435	.7	
0723	49	
1018	1.7	
1323	<.018	
1623	2.4	
1923	.11	
2223	.49	
1/0123	.49	
0423	.79	.17
0723	.79	.23
1023	2.8	.078
1323	.49	.23
1623	.34	.79
1923	.7	.46
2223	.33	.33
2/0133	1.7	
0423	.95	
1030	1.1	

MILE 58.2

(1)	(2)	(3)
29/0944	.79	
1235	16	
1544	24	
1844	3.5	
2144	5.4	
30/0044	5.4	.037
0344	1.7	.13
0604	5.4	.082
0940	.79	.045
1244	5.4	.045
1544	2.4	.33
1844	3.5	.13
2144	1.3	.14
31/0044	.7	
0344	.49	
0644	1.1	
0944	2.2	
1244	2.4	
1544	5.4	
1844	.49	
2144	.33	
1/0044	1.7	.02
0344	.95	.078
0644	700	130
0944	.79	.14
1244	.49	2.4
1544	.79	.79
1844	.79	.33
2144	3.5	1.3
2/0120	1.7	
0347	.79	
1011	1.7	

MILE 54.2

(1)	(2)	(3)
29/0903	5.4	
1203	2.4	
1503	1.7	
1804	2.2	
2103	2.4	
30/0003	5.4	.045
0303	5.4	1.1
0617	16	2.8
0908	5.4	.79
1203	1.3	.33
1503	1.3	.068
1803	1.3	.13
2103	.79	.11
13/0003	1.3	
0306	1.4	
0604	.79	
0903	.078	
1203	3.5	
1503	2.4	
1803	1.1	
2103	1.3	
1/0003	.79	.068
0303	.79	.79
0603	1.7	.23
0903	2.4	.49
1203	2.2	.13
1503	1.2	.23
1803	.79	.17
2103	1.3	1.3
2/0100	.49	
0303	1.7	
0742	1.3	

MILE 50.8

(1)	(2)	(3)
29/1055	2.7	
1338	1.3	
1700	46	
2003	23	
30/0440	1.7	.18
0730	4.9	4.9
1050	2.3	1.3
1347	7.9	
1646	1.7	.68
2010	4.9	.2
2253	7.9	4.9
31/0145	11	
0450	4.9	
0750	22	
1047	3.3	
1356	17	
1650	3.3	
1952	3.3	
2249	1.3	
1/0200	7.9	7.9
0455	3.3	3.3
0800	3.3	.78
1100	3.3	2.2
1358	4.9	1.7
1655	33	1.3
2003	4.9	2.2
2256	7.9	.61
2/0155	11	
0455	13	
0802	7.9	

MILE 48.4

(1)	(2)	(3)
29/1026	3.3	
1329	1.3	
1636	3.3	
1945	2.2	
2221	1.7	
30/0415	4.9	.68
0705	2.2	.45
1025	23	2.2
1333	11	
1624	2.3	1.3
1948	7	.2
2234	13	7.9
31/0123	79	
0430	17	
0733	2.3	
1025	3.3	
1339	22	
1629	3.3	
1932	4.9	
2224	3.3	
1/0134	4.6	<.18
0432	54	.61
0734	4.9	.4
1035	2.3	.78
1333	2.3	1.3
1632	13	1.4
1951	7.9	4.9
2234	7.9	<.18
2/0134	3.3	
0433	92	
0733	35	

MILE 46.3

(1)	(2)	(3)
29/0949	1.7	
1252	3.3	
1610	2.1	
1922	2.2	
2202	4.9	
30/0353	7.9	.45
0645	4.9	.68
1000	4.6	.68
1308	23	3.3
1612	12	3.3
1917	11	1.2
2204	4.9	2.2
31/0101	7.9	
0406	35	
0708	24	
0958	13	
1311	11	
1609	12	
1907	2.3	
2206	17	
1/0112	54	1.7
0412	24	3.3
0715	35	1.1
1002	24	4.9
1313	7.9	3.3
1615	7.9	4.9
1919	7.9	7.9
2211	4.9	1.3
2/0113	35	
0407	54	
0713	13	

MILE 43.4

(1)	(2)	(3)
29/0935	1.7	
1233	4.9	
1551	4.9	
1908	7.9	
2145	3.3	
30/0335	13	1.3
0630	24	1.4
0935	130	.78
1240	33	.68
1556	16	2.1
1845	7.9	.93
2145	7.9	.78
31/0045	3.3	
0343	>240	
0645	54	
0930	54	
1237	54	
1536	24	
1840	17	
2138	7.9	
1/0044	4.6	.78
0351	24	4.9
0644	13	1.4
0943	24	17
1245	24	7.9
1544	24	13
1844	24	24
2143	3.3	4.9
2/0043	7	
0348	4.9	
0641	92	

MILE 39.8

(1)	(2)	(3)
29/0909	1.7	
1208	3.3	
1530	4.9	
1830	1.3	
2117	4.9	
30/0300	3.2	.45
0605	4.9	.45
0905	130	.45
1158	7.8	<.18
1524	70	1.8
1809	49	2
2120	2.4	4.5
31/0020	33	
0315	>240	
0609	3	
0908	54	
1202	24	
1507	35	
1807	92	
2109	4.9	
1/0009	24	.45
0325	13	1.3
0512	11	7
0905	54	54
1209	35	35
1317	35	35
1808	24	24
2113	.79	.02
2/0008	4.6	
0320	13	
0609	4.9	

MILE 37.2

(1)	(2)	(3)
29/0915	3.3	
1222	3.3	
1518	3.3	
1823	3.1	
2143	4.9	
30/0028	2.1	.18
0337	7.9	.4
0559	4.6	1.1
0920	7.9	13
1226	22	2
1522	33	1.3
1814	33	1.7
2122	13	13
31/0034	79	
0340	5.4	
0547	1.3	
0938	17	
1247	13	
1513	54	
1821	35	
2124	28	
1/0022	35	24
0321	24	24
0550	2.2	4.9
0915	3.3	4.9
1238	13	13
1522	35	24
1823	17	13
2122	3.5	.078
2/0023	2.4	
0335	17	
0605	4.9	

MILE 34.4

(1)	(2)	(3)
29/0855	4.6	
1200	3.3	
1500	3.1	
1803	1.1	
2122	2.3	
2359	1.7	.45
30/0312	1.1	<.18
0544	3.3	.4
0828	1.7	1.7
1208	3.3	.018
1553	7.8	
1758	13	
2058	3.3	.78
31/0010	3.3	
0314	24	
0533	17	
0919	7.9	
1231	7	
1458	4.9	
1802	24	
2106	35	
2400	17	3.1
1/0303	17	22
0540	24	13
0850	4.9	7.9
1217	4.9	3.3
1508	7.9	4.9
1805	13	13
2103	5.4	1.7
2/0003	.79	
0310	2.3	
0551	3.3	

MILE 27.4

(1)	(2)	(3)
29/0935	1.3	
1245	5.4	
1545	1.7	
1850	2.4	
2150	.79	
30/0110	3.5	.02
0410	.78	.2
0655	1.3	.2
0950	.49	.068
1235	.49	.018
1550	.79	
1850	.79	
2145	.79	.068
31/0630	3.5	
0910	7.2	
1245	16	
1655	3.5	
2000	3.5	
2302	1.3	
1/0217	3.5	.34
0506	.35	.54
0804	4.4	.14
1103	3.5	.23
1403	9.2	5.4
1700	1.7	3.5
2008	2.4	.045
2306	2.4	
2/0210	17	
0514	5.4	

MILE 23.3

(1)	(2)	(3)
29/0905	.79	
1155	.17	
1509	.33	
1815	2.2	
2120	.33	
30/0030	1.3	.02
0330	1.1	.078
0620	.4	.18
0915	.49	.045
1200	3.3	.078
1510	1.3	
1810	.49	
2055	.33	.02
31/0605	3.5	
0840	1.3	
1155	.23	
1445	.17	
1750	4.4	
1/0015	.49	<.018
0315	1.3	.79
0605	5.4	2.4
0840	5.4	5.4
1145	1.3	.79
1455	1.3	.79
2/0245	.045	
0540	5.4	
0830	5.4	
1145	1.3	

MILE 18.8

(1)	(2)	(3)
29/0825	.46	
1105	.33	
1410	1.3	
1740	.49	
2045	.33	
2345	.79	<.018
30/0245	.7	.045
0540	.45	<.18
0845	.33	.04
1135	.49	.04
1425	.49	
1730	.17	<.018
2025	1.1	.11
31/0535	1.3	
0810	.33	
1110	.49	
1410	.21	
1710	.33	
2350	1.1	.13
1/0225	.79	.22
0510	1.3	1.3
0815	.17	.17
1105	.46	.31
1415	1.3	.23
2/0205	1.3	
0500	.49	
0755	1.3	
1105	.49	

MILE 15.1

(1)	(2)	(3)
29/----	.46	
1030	.17	
1450	.17	
1725	.31	
2045	.13	
2343	.33	.02
30/1400	.49	
1650	.46	
2020	.49	.22
2305	.17	
31/0217	.95	
0520	2.2	
1355	.33	
1630	.17	
1928	1.1	
2245	.46	
1/1357	2.2	.17

MILE 13.4

(1)	(2)	(3)
29/1020	.49	
1400	.31	
1707	.13	
2020	1.3	
2320	.79	.33
30/0255	.26	.04
0543	.33	<.018
0746	.31	.061
1057	2.4	.46
1342	.64	
1634	.33	.078
2000	1.1	.13
2250	.79	.23
31/0158	.068	
0506	.33	
0745	1.3	
1037	1.3	
1340	.33	
1614	.31	
1912	.79	
2230	9.2	
1/0135	2.4	1.3
0420	.31	.13
0750	.49	.11
1046	.33	.17
1340	1.3	.49
1632	.21	.078
1940	3.5	.045
2245	.33	.13
2/0125	1.1	
0409	.32	
0717	.23	

MILE 9.5

(1)	(2)	(3)
29/1336	1.7	
1636	.33	
1946	.22	
2243	.49	
30/0207	2.4	.23
0520	1.4	.23
0714	1.4	.46
0920	1.3	.11
1315	.33	.11
1610	1.3	.17
1930	<.018	
2223	.17	.02
13/0130	.33	
0442	2.4	
0717	1.3	
1015	1.1	
1315	.13	
1548	9.2	
1848	1.3	
2206	.23	
1/0107	.33	.22
0355	2.4	.23
0725	.49	.33
1020	.79	.49
1315	.49	.49
1605	.79	.33
1916	1.3	.33
2220	.33	.23
2/0058	.33	
0347	3.5	
0655	1.3	

MILE 4.0

(1)	(2)	(3)
29/0922	3.5	
1240	.49	
1600	.17	
1912	3.5	
2150	2.4	
30/0115	1.3	.33
0445	.14	<.018
0640	.17	.04
0942	1.3	.14
1230	1.3	
1525	.49	
1850	1.1	.13
2143	.33	.33
31/0645	1.1	
0942	.49	
1335	5.4	
1510	1.3	
1817	.33	
2135	1.3	
1/0030	1.3	1.3
0317	1.7	1.1
0645	.078	.078
0948	.33	.13
1238	5.4	3.5
1523	1.3	.79
1845	.23	.13
2200	.7	.13
2/0025	2.4	
0322	2.4	
0630	.078	

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.
(3) Fecal coliform bacteria, MPN/100 ml, thousands.

TABLE T-1 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

2nd LOWER REACH INTENSIVE SAMPLING PROGRAM

AUGUST 29-SEPTEMBER 2, 1960
(Continued)

NATOMAS EAST MAIN DRAIN
MILE 60.6L

(1)	(2)	(3)
29/1040	.84	
1655	17	
2235	7	
30/1040	14	1.1
1645	4.9	
31/0440	9.5	
1040	54	
1640	17	
2240	14	
1/0415	11	3.3
1040	4.6	2.3
1645	17	4.6
2245	4.9	4.9
2/0440	7.9	
1040	13	

AMERICAN RIVER
MILE 60.4L

(1)	(2)	(3)
29/1015	9.2	
1615	24	
2215	16	
30/0415	5.4	.018
1015	5.4	.061
1615	9.2	.45
2220	5.4	
31/0415	2.3	
1015	7.9	
1615	3.3	
2215	4.6	
1/0415	4.9	<.18
1015	3.3	<.18
1615	4.9	1.7
2215	7	4.6
2/0415	7.9	
1015	4.6	

WEST SACRAMENTO SEWAGE TREATMENT PLANT
MILE 58.0R

(1)	(2)	(3)
29/1120	<18	
1730	.93	
2320	2,400	2,400
30/1120	<.18	<.18
1720	<.18	
2325	2,400	
31/0520	.078	
1120	.23	
1720	2.4	
2320	2.4	.13
1/0520	16	16
1120	.23	.018
1700	3.3	<.18
2335	9.2	
2/0520	.2	
1120	<.18	

SACRAMENTO SEWAGE TREATMENT PLANT
MILE 54.1L

(1)	(2)	(3)
29/0900	<18	
1200	<18	
1500	20	
1800	45	
2100	130	
2400	45	<18
30/0304	45	<18
0614	140	<18
0906	20	<18
1200	45	<18
1500	270	<18
1800	170	
2100	230	45
2400	78	
31/0200	40	
0600	.49	
0900	49	
1200	540	
1500	17	
1800	130	
2100	61	
2400	17	<1.8
1/0300	33.	<1.8
0600	.48	.17
----	460	2
1200	330	230
1500	79	79
1800	33	33
2100	49	33
2/0155	.79	
0200	33	
0740	350	

MEADOWVIEW SEWAGE TREATMENT PLANT
MILE 47.7L

(1)	(2)	(3)
29/0905	16,000	
1500	16,000	
2105	13,000	
30/0305	35,000	3,500
0905	4,600	4,600
1505	24,000	13,000
2105	54,000	54,000
31/0305	7,900	
0905	54,000	
1505	13,000	
2105	160,000	
1/0305	17,000	17,000
0905	13,000	4,900
1505	54,000	54,000
2105	17,000	35,000
2/0305	24,000	
0905	24,000	

AMERICAN CRYSTAL SUGAR COMPANY
MILE 43.3R

(1)	(2)	(3)
29/1355	790	
2000	920	
30/0225	540	11
0800	540	11
1400	240	79
1945	17	.82
31/0205	450	
0810	330	
1350	260	
1930	7,000	
1/0205	68	45
0800	450	170
1400	490	
2000	3,500	2,300
2400	490	
2/0150	450	

ISLETON SEWAGE TREATMENT PLANT
MILE 18.1L

(1)	(2)	(3)
29/1230	<1.8	
1845	<1.8	
30/0030	<1.8	<18
0645	<1.8	<1.8
1230	<18	
1815	<18	<18
31/0030	<18	
0630	<.018	
1205	24	
1800	.79	
1/0025	3.5	.02
0635	3.3	<.018
1210	.045	.078
1805	1.7	1.3
2/0025	2.4	
0615	<.018	

RIO VISTA SEWAGE TREATMENT PLANT
MILE 11.6R

(1)	(2)	(3)
29/1200	13,000	
1700	11,000	
2330	13,000	5,400
30/0545	16,000	5,400
1200	13,000	
1740	17,000	7,000
2330	3,300	
31/0530	240,000	
1045	35,000	
1710	4,900	
2400	35,000	24,000
1/0600	7,900	4,900
1100	13,000	13,000
1710	4,900	4,900
2330	13,000	
2/0545	11,000	

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.
(3) [illegible]

TABLE T-I (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

3rd LOWER REACH INTENSIVE SAMPLING PROGRAM

OCTOBER 24-28, 1960

MILE 62.6

(1)	(2)
24/1050	.49
1438	.49
1700	.79
2330	.33
25/0456	.33
0745	.79
1030	1.1
1410	.79
1642	.49
2007	.79
2257	.7
26/0154	.23
0620	.22
0820	.17
1130	.49
1435	.44
1725	.49
2039	.33
2330	.33
27/0137	.31
0403	.23
0724	.21
1033	.46
1342	5.4
1830	.79
2045	.23
2255	.33
28/0152	.12
0448	.068
0743	.49

MILE 58.2

(1)	(2)
24/1022	.33
1400	1.1
1629	.33
2248	.49
25/0418	.13
0658	2.4
1000	.078
1338	.33
1615	.79
1937	.49
2218	.27
26/0122	.49
0543	.31
0752	.27
1058	.7
1400	.49
1655	1.3
2003	.23
2247	1.3
27/0105	.33
0411	.79
0656	.11
1003	.093
1318	.33
1750	.23
2020	.49
2230	.33
28/0117	.23
0418	.33
0714	.49

MILE 54.2

(1)	(2)
24/0952	.13
1305	.49
1603	.7
2048	.13
2210	.34
25/0348	.7
0641	.49
0944	3.5
1310	.49
1547	1.3
1908	.49
2258	.33
26/0103	.31
0520	.33
0733	.22
1045	.13
1630	.33
1940	1.1
2220	.79
27/0043	.33
0350	1.4
0645	.33
0950	.46
1255	.49
1654	.33
1952	.17
2205	.23
28/0059	1.3
0404	.11
0657	.23

MILE 50.8

(1)	(2)
24/1217	7
1732	4.9
2205	3.3
25/0005	13
0240	17
0527	7.9
0818	2.7
1107	7.1
1427	49
1714	7
2102	7.9
2345	7.9
26/0240	49
0615	7.9
0848	7.9
1147	11
1437	4.9
1747	11
2058	3.3
2332	2.3
27/0242	4.9
0540	17
0815	2.3
1114	16
1423	5.4
1728	16
2040	9.2
2338	5.4
28/0224	9.2
0524	2.8
0830	3.5

MILE 48.4

(1)	(2)
24/1158	7.9
1716	17
2147	7.9
2352	7.9
25/0224	7
0514	4.9
0806	4.6
1113	4.6
1413	4.9
1658	1.1
2043	7.9
2323	7
26/0218	7.9
0602	14
0828	7
1126	7.9
1420	7.9
1727	3.3
2040	17
2314	7.9
27/0230	11
0521	3.5
0800	5.4
1055	5.4
1404	>24
1712	3.5
2024	16
2317	9.2
28/0207	5.4
0508	9.2
0811	3.5

MILE 46.3

(1)	(2)
24/1020	7.9
1700	11
2100	7.9
2326	35
25/0155	13
0448	7
0750	3.3
1048	11
1358	14
1640	7
2018	17
2301	17
26/0105	7.9
0528	18
0758	3.3
1108	22
1353	17
1656	3.1
2013	11
2255	13
27/0202	22
0455	9.2
0745	9.2
1040	16
1346	5.4
1652	2.4
2004	16
2258	9.2
28/0152	>24
0450	16
0755	9.2

MILE 43.4

(1)	(2)
24/1055	7.9
1643	23
2032	35
2305	7.9
25/0140	11
0430	4.9
0733	13
1030	17
1338	4.6
1624	11
2000	13
2240	4.9
26/0136	17
0500	7.9
0735	4.9
1047	7.9
1333	11
1636	9.5
1953	11
2236	23
27/0142	11
0440	1.6
0729	9.2
1025	9.2
1328	16
1632	9.2
1947	9.2
2038	16
28/0132	3.5
0433	>24
0737	16

MILE 39.8

(1)	(2)
24/1020	7
1606	13
1944	17
2240	4.9
25/0110	7.9
0407	4.9
0710	17
1005	13
1305	11
1600	3.3
1930	7.9
2208	17
26/0110	4.9
0425	4.9
0707	4.9
1009	4.9
1300	3.5
1605	4.9
1922	13
2206	17
27/0107	13
0406	5.4
0705	16
1004	9.2
1304	9.2
1604	5.4
1918	9.2
2204	16
28/0106	16
0410	16
0710	>24

MILE 37.2

(1)	(2)
24/1025	7
1338	11
2310	3.3
25/0060	7
0137	7.9
0534	7.9
0708	13
1703	7
1952	2.3
2240	7.9
26/0235	3.3
0434	1.1
0745	3.3
1021	7.9
1330	6.4
1600	14
1906	11
2250	7.9
27/0202	49
0423	16
0710	9.2
1007	3.5
1310	3.5
1602	>24
1953	>24
2205	5.4
28/0135	16
0422	16
0644	2.4

MILE 34.4

(1)	(2)
24/1006	3.3
1310	13
1613	14
2225	7
25/0118	4.9
0510	11
0655	3.3
1633	3.4
1927	2.2
26/0214	7
0414	7.9
0732	3.3
1007	7.9
1305	2.2
1540	3.3
1845	11
2220	4.9
27/0140	4.9
0405	>24
0654	9.2
0952	5.4
1250	1.1
1540	3.5
1934	>24
2145	16
28/0114	9.2
0403	5.4
0633	3.5

MILE 27.4

(1)	(2)
24/1115	5.4
1330	5.4
2215	3.5
25/0050	.7
0230	3.5
0740	3.5
0945	5.4
1235	2.2
2000	3.3
2235	1.3
26/0135	1.7
0425	3.3
0705	4
1005	1.7
1230	3.3
1525	2.7
1840	2.3
2200	2.3
27/0115	3.3
0440	4.9
0745	1.3
1355	4.9
1525	4.6
1835	.31
2140	7.9
28/0100	2.3
0345	3.3
0730	3.3

MILE 23.3

(1)	(2)
24/1040	2.4
1300	1.7
2135	1.8
25/0150	3.5
0630	1.7
0920	.33
1205	1.3
1930	1.1
2205	.33
26/0100	1.4
0345	2.2
0630	.79
0930	5.4
1210	1.1
1505	2.4
1815	1.7
2130	3.5
27/0045	1.7
0400	3.5
0700	.23
0925	1.3
1335	.46
1505	2.2
1810	2.2
2115	3.5
28/0020	.33
0310	3.5
0640	3.5

MILE 18.8

(1)	(2)
24/1015	.33
1230	.49
25/0605	2.8
0855	.49
1140	1.1
1905	.33
2135	.49
26/0010	1.3
0315	.49
0600	.49
0850	.46
1145	.49
1445	.49
1745	.79
2110	.33
27/0010	1.3
0330	.23
0610	.49
1445	1.7
1745	.33
2055	1.3
2350	.33
28/0245	.79
0610	.79

MILE 13.4

(1)	(2)
24/0910	.7
1145	.49
1435	1.3
1735	1.3
2050	1.3
2350	.49
25/0240	.33
0510	.7
0845	.31
1140	.49
1440	.49
1725	1.7
2120	.79
2350	1.7
26/0245	.7
0455	.49
0840	.79
1143	.49
1500	.33
1800	.33
2105	.33
2340	.23
27/0255	.31
0850	.11
1139	.23
1435	.23
1730	.23
2040	.49
2330	.33
28/0245	.21
0540	.23

MILE 9.5

(1)	(2)
24/0840	1.3
1122	.7
1410	1.1
1715	.49
2030	.79
2330	2.4
25/0210	.49
0445	1.1
0820	1.1
1115	.79
1415	2.4
1705	.49
2055	.46
2330	.79
26/0220	2.2
0430	1.7
0820	1.7
1118	1.3
1435	1.3
1735	.49
2040	.33
2310	.79
27/0220	.13
0827	.49
1115	.79
1415	.31
1705	1.3
2020	.49
2305	.49
28/0215	1.1
0510	.49

MILE 4.0

(1)	(2)
24/1042	.79
1335	.33
1640	3.5
1955	2.4
2245	1.1
25/0140	.49
0407	.33
0750	1.1
1040	.7
1345	1.3
1630	1.7
2020	1.7
2245	.7
26/0145	.33
0410	.49
0755	5.4
1045	1.7
1355	.49
1700	.49
2005	.79
2230	.33
27/0140	.33
0807	2.4
1145	2.2
1340	.33
1630	.7
1945	1.7
2235	1.7
28/0140	.33
0430	.79
0710	.49

NATOMAS MAIN MAIN DRAIN MILE 60.6L

(1)	(2)
24/1140	4.9
1750	33
2355	11
25/0545	11
1140	7.9
1740	11
2345	3.3
26/0540	7.9
1040	7.9
1745	130
2345	2.3
27/0540	2.3
1130	3.3
1745	2.3
2345	2.4
28/0540	2.4

SACRAMENTO SEWAGE TREATMENT PLANT MILE 60.4L

(1)	(2)
24/1115	.23
1730	4.9
2335	.7
25/0515	2.4
1110	1.3
1715	11
2315	5.4
26/0510	.79
1115	1.1
1715	1.3
2315	1.3
27/0510	.49
1110	.79
1715	.79
2315	.49
28/0515	1.3

WEST SACRAMENTO SEWAGE TREATMENT PLANT MILE 58.0R

(1)	(2)
24/1210	.78
1825	<.18
25/0025	.2
0620	17
1210	.78
1820	.4
26/0025	<.18
0630	<.18
1210	<.018
1820	<1.8
27/0015	.17
0625	35
1215	.078
1815	1.3
28/0015	<.018
0620	<.018

SACRAMENTO SEWAGE TREATMENT PLANT MILE 54.1L

(1)	(2)
24/1600	>24
25/0345	>24
0630	70
0942	>24
1305	220
1542	79
1905	28
2150	170
26/0100	33
0516	49
0728	540
1043	>2,400
1320	540
1625	170
1938	79
2218	220
27/0040	79
0347	240
0643	130
0947	110
1253	220
1648	49
1950	33
2200	220
28/0056	79
0401	170
0653	33

MEADOWVIEW SEWAGE TREATMENT PLANT MILE 47.7L

(1)	(2)
24/1005	17,000
1605	22,000
2203	54,000
25/0410	35,000
1005	160,000
1605	35,000
2205	33,000
26/0355	17,000
1005	70,000
1605	7,800
2205	13,000
27/0405	33,000
1000	46,000
1605	13,000
2200	79,000
28/0405	23,000

AMERICAN CRYSTAL SUGAR COMPANY MILE 43.3R

(1)	(2)
24/1540	170
2200	170
25/0400	49,000
0855	130
1700	130
2145	280
26/0245	790
0853	330
1435	310
2135	490
27/0300	3,500
0855	490
1420	950
2055	170
28/0230	170
0830	490

ISLETON SEWAGE TREATMENT PLANT MILE 18.1L

(1)	(2)
24/1345	4.9
1945	92
25/0128	1.7
0740	35
1400	160
2000	540
26/0120	4.5
0733	17
1245	33
1955	220
27/0120	70
0735	17
1300	79
1730	1,600
28/0100	13
0715	<1.8

RIO VISTA SEWAGE TREATMENT PLANT MILE 11.6R

(1)	(2)
25/1330	17,000
1940	13,000
26/0025	54,000
0705	14,000
1200	54,000
1910	13,000
27/0047	240
0707	11,000
1200	11,000
1900	17,000
28/0025	35,000
0650	14,000

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.

TABLE T-1 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF COLIFORM ANALYSES

LOG PONDS

SEPTEMBER 29, 1960

Name	(1)	(2)
M & F Lumber Co.	.13	3.5
Sunshine Lumber Co.	1.1	9.2
M & F Lumber Co.	.79	9.2
M & F Lumber Co.	.13	3.5
Sunshine Lumber Co.	.15	.45
Daniels Lumber Co.	.078	.21
Sunshine Lumber Co.	.02	16
M & F Lumber Co.	.26	2.8
Daniels Lumber Co.	.078	.13
Daniels Lumber Co.	.13	.64
Daniels Lumber Co.	.14	1.3
Sunshine Lumber Co.	<.0018	1.8
Diamond National Corp.	.068	.28
U. S. Plywood (NE pond)	.13	.81
Diamond National Corp. (center pond)	2.2	>24
U. S. Plywood (SW pond)	1.1	9.2
U. S. Plywood (NW pond)	5.4	>24
U. S. Plywood (SE area pond)	.22	2.2
R. Smith Lumber Co. (N end)	.045	1.7
R. Smith Lumber Co. (center)	<.0018	.17
R. Smith Lumber Co. (S end)	.2	7.9

(1) Date/Time
(2) Coliform bacteria, MPN/100 ml, thousands.

TABLE T-2

SACRAMENTO RIVER WATER POLLUTION SURVEY

PLANKTON SURVEY DATA

1960 – 1961

STATION NO. 1

Location: Above Spring Creek — River Mile: 305.7

	1960									1961					
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	130	380	260	120	190	95	91	86			120		540		450
Standard Areal Units/ml	78	190	140	34	60	75	24	20			35		120		160
DOMINANT FORMS[1]	11	11,12	10	10	13	10	10	10			31		10		10
BLUE GREENS															
Coccoid No.[2]	4.3	9.6													
" SU[3]	9.1	1.4													
" %[4]	3.7	2.5													
Filamentous No.		4.8			2.4	4.8									
" SU		60			1.0	22									
" %		1.3			1.3	5.1									
GREENS															
Coccoid No.	19	86	41	22	26	9.6							130		120
" SU	2.4	34	4.1	22	2.9	1.0							13		12
" %	14.6	22.7	15.8	18.3	13.7	10.0							24.1		26.7
Filamentous No.			2.4												
" SU			18												
" %			0.9												
FLAGELLATES															
Pigmented No.					14										
" SU					3.8										
" %					7.4										
Unpigmented No.															
" SU															
" %															
DIATOMS															
Centric No.	29	34	50	14	24	14	29	9.6			72		140		28
" SU	44	24	34	68	24	37	13	1.9			23		42		23
" %	22.3	9.3	19.2	11.7	12.6	14.8	31.9	11.1			60.0		25.9		6.1
Pennate No.	82	250	160	83	120	67	62	72			53		270		300
" SU	23	75	64	25	31	15	11	13			12		60		120
" %	63.1	65.9	61.5	69.2	63.3	70.5	68.2	83.8			44.2		50.0		66.7
PROTOZOA															
Sarcodina No.			4.8												
" SU			16												
" %			1.8												
Ciliates No.								4.8							4.6
" SU								4.8							1.8
" %								5.6							1.0
ROTIFERS No.			2.4												
" SU			3.6												
" %			0.9												
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.															
" SU															
" %															

STATION NO. 2

Location: Above Redding Div. Dam — River Mile: 297.7

	1960									1961					
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	210	360	170	140		87	110	140	170	280				770	
Standard Areal Units/ml	88	86	45	39		28	40	350	48	90				180	
DOMINANT FORMS[1]	10	10	10	10		10	10	30	10	10				10,20	
BLUE GREENS															
Coccoid No.[2]	14		2.4												
" SU[3]	1.0		0.2												
" %[4]	6.7		1.4												
Filamentous No.	4.8		2.4												
" SU	12		0.7												
" %	2.3		1.4												
GREENS															
Coccoid No.	43	91	50	29		9.6	4.8	4.8	9.6	4.8				290	
" SU	4.3	15	72	5		1.0	0.5	42	1.0	.5				29	
" %	20.5	25.3	29.5	20.7		11.0	4.4	3.4	5.6	1.7				37.7	
Filamentous No.	4.8														
" SU	29														
" %	2.3														
FLAGELLATES															
Pigmented No.									4.8						
" SU									3.4						
" %									2.8						
Unpigmented No.															
" SU															
" %															
DIATOMS															
Centric No.	34	14	19	17		7.2	34	43	43	67				46	
" SU	14	14	12	14		9.6	20	290	11	26				13	
" %	16.2	3.9	11.2	12.2		8.3	30.9	30.7	25.3	23.9				6.0	
Pennate No.	110	250	100	91		70	72	96	110	210				430	
" SU	28	57	25	20		17	20	17	33	64				140	
" %	52.3	69.5	58.9	65.0		80.5	65.5	68.6	64.8	75.2				55.8	
PROTOZOA															
Sarcodina No.															
" SU															
" %															
Ciliates No.															
" SU															
" %															
ROTIFERS No.															
" SU															
" %															
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.															
" SU															
" %															

STATION NO. 5

Location: Above Churn Creek — River Mile: 285.9

	1960									1961					
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	530	650	460	440	140	260	550	580	220	590	220			1200	
Standard Areal Units/ml	240	350	320	180	140	100	220	310	65	150	140			380	
DOMINANT FORMS[1]	10	20	10	10	30	10	10	30	10	10	10			10	
BLUE GREENS															
Coccoid No.[2]	4.8	14	4.8												
" SU[3]	0.5	1.9	1.2												
" %[4]	0.9	2.2	1.0												
Filamentous No.	4.8	9.6	4.8		12		9.6	4.8	4.8	4.8	4.8				
" SU	1.0	20	3.8		8.9		3.8	2.9	2.4	7.2	3.4				
" %	0.9	1.5	1.0		8.6		1.7	0.8	2.2	0.8	2.1				
GREENS															
Coccoid No.	77	140	65	62	14	9.6	29	14	4.8					320	
" SU	7.7	16	18	74	1.4	1.2	3.0		5.8	.5				32	
" %	14.5	21.5	14.1	14.1	10.0	3.7	5.3		6.4	0.8				26.7	
Filamentous No.	9.6	14			2.4						4.8			9.2	
" SU	43	44			45						30			25	
" %	1.8	2.2			1.7						2.1			0.8	
FLAGELLATES															
Pigmented No.		4.8	2.4		7.2	2.4			4.8	4.8					
" SU		7.7	9.1		6.7	0.5			1.4	4.8					
" %		0.7	0.5		5.1	0.9			2.2	0.8					
Unpigmented No.															
" SU															
" %															
DIATOMS															
Centric No.	62	48	72	53	31	26	86	190	34	77	53			32	
" SU	41	47	92	36	41	43	99	170	23	25	29			36	
" %	11.7	7.4	15.7	12.1	22.1	10.0	15.6	32.8	15.5	13.1	23.3			2.7	
Pennate No.	370	410	310	330	67	220	430	380	160	500	160		880		
" SU	130	200	120	68	32	60	110	140	32	110	73			290	
" %	69.9	63.2	67.4	75.1	47.9	84.7	78.2	65.5	72.7	84.7	70.5			73.3	
PROTOZOA															
Sarcodina No.	4.8	4.8													
" SU	14	14													
" %	0.9	0.7													
Ciliates No.					4.8										
" SU					4.8										
" %					3.4										
ROTIFERS No.			2.4												
" SU			79												
" %			0.5												
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.															
" SU															
" %															

STATION NO 6

Location: Balls Ferry Bridge — River Mile: 275.0

	1960									1961					
	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	780	940	500	510	310	420	800	530	200	380	230		640		1300
Standard Areal Units/ml	370	640	330	200	180	170	350	240	70	120	130		180		430
DOMINANT FORMS[1]	10	10	10	10	30	10	10	30	10	10	10		10		10
BLUE GREENS															
Coccoid No.[2]		4.8	2.4												
" SU[3]		1.0	0.2												
" %[4]		0.5	0.5												
Filamentous No.	4.8	24	4.8	12	9.6	9.6	19	4.8			24		24		18
" SU	2.0	49	5.3	10	7.4	9.6	9.1	10			18		7.2		8.3
" %	0.6	2.6	1.0	2.4	3.1	2.3	2.4	0.9			10.4		2.2		1.4
GREENS															
Coccoid No.	120	120	60	48	12	17	14		9.6		9.6		120		300
" SU	12	16	15	12	1.7	1.7	1.4		1.0		1.0		12		32
" %	15.4	12.8	12.0	9.4	3.9	4.0	1.7		4.8		4.2		18.7		23.1
Filamentous No.	14	19	2.4								9.6				9.2
" SU	76	84	1.9								43				21
" %	1.8	2.0	0.5								4.2				0.7
FLAGELLATES															
Pigmented No.	9.6	4.8			2.4		4.8	4.8		14					
" SU	0.5	14			2.4		3.8	2.4		4.3					
" %	1.2	0.5			0.8		0.6	0.9		3.7					
Unpigmented No.															
" SU															
" %															
DIATOMS															
Centric No.	58	100	110	67	50	41	96	150	48	86	38		48		60
" SU	59	180	170	80	82	30	110	140	38	26	18		29		96
" %	7.4	10.6	22.0	13.1	16.1	9.8	12.0	28.3	24.0	22.6	16.5		7.5		4.6
Pennate No.	570	660	320	380	240	350	670	370	140	270	150		460		900
" SU	220	280	110	100	89	93	230	91	31	87	38		130		270
" %	73.2	70.2	64.0	74.5	77.4	83.3	83.8	69.8	70.0	71.1	65.2		71.9		69.2
PROTOZOA															
Sarcodina No.		4.8	4.8												
" SU		7.2	26												
" %		0.5	1.0												
Ciliates No.										4.8					
" SU										2.4					
" %										1.3					
ROTIFERS No.		0.5													
" SU		6.6													
" %															
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.							4.8								
" SU						36									
" %							1.2								

1 See code at end of table for identification.
2 Number of plankton in given group/ml.
3 SU = Standard Areal Units/ml.
4 % = Number of plankton/ml in given group as percent of total plankton/ml.

TABLE T-2 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

PLANKTON SURVEY DATA

1960–1961

STATION NO 7

Location: Bend Bridge — River Mile: 256.3

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
	1960									1961					
TOTAL PLANKTON Number/ml	650	490	770	470	450	570	940	1000		340				1700	
Standard Areal Units/ml	430	350	440	230	200	230	420	500		170				710	
DOMINANT FORMS[1]	10	10	10	10	10	10	10	10		10				10	
BLUE GREENS															
Coccoid No.[2]				2.4				4.8							
" SU[3]				0.2				1.0							
" %[4]				0.5				0.5							
Filamentous No.	4.8	24	4.8	19	17	17	14	29						23	
" SU	2.4	36	7.4	14	16	19	22	33						20	
" %	0.7	0.5	0.6	4.0	3.9	3.0	1.5	2.9						1.3	
GREENS															
Coccoid No.	86	62	77	34	22	9.6	38	24		4.8				280	
" SU	9.1	13	11	12	6.2	1.9	6.7	5.0		[illegible]				31	
" %	13.2	12.7	10.0	7.2	4.9	1.7	4.0	2.4		1.2				16.5	
Filamentous No.		4.8		2.4										23	
" SU		8.9		9.1										89	
" %		1.0		0.5										1.3	
FLAGELLATES															
Pigmented No.		2.4		4.8	7.2	4.8								14	
" SU		3.1		7.4	3.4	4.8								9.7	
" %		0.5		1.0	1.6	0.8								0.8	
Unpigmented No.															
" SU															
" %															
DIATOMS															
Centric No.	62	67	160	72	62	48	120	180		29				51	
" SU	94	71	230	85	74	65	140	170		19				62	
" %	9.5	13.7	20.8	15.3	13.8	8.4	12.8	18.0		8.1				3.0	
Pennate No.	490	340	530	340	340	490	760	780		330				1300	
" SU	220	160	190	98	100	140	250	200		110				490	
" %	75.5	69.3	68.9	72.5	75.7	86.0	80.9	78.0		88.9				76.5	
PROTOZOA															
Sarcodina No.	9.6	2.4													
" SU	35	6.[illegible]													
" %	1.5	0.5													
Ciliates No.		12					4.8							4.6	
" SU		80					3.8							9.2	
" %		2.5					0.5							0.3	
ROTIFERS No.		0.2													
" SU		3.7													
" %															
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.										4.8					
" SU										36					
" %										1.2					

STATION NO. 10

Location: Above Elder Creek — River Mile: 229.

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
	1960									1961					
TOTAL PLANKTON Number/ml	1300	1200	770	740	1800	760	1200	1100	170	540	260		890	2900	2500
Standard Areal Units/ml	720	720	500	370	620	250	420	460	30	170	85		300	1000	780
DOMINANT FORMS[1]	10	10	10	31	10	10	10	10	10	10	10		10,20	10	10
BLUE GREENS															
Coccoid No.[2]	4.8		12												
" SU[3]	0.5		1.7												
" %[4]	0.4		1.6												
Filamentous No.		36	19	17	26	9.6	29	4.8		9.6			9.6	4.6	37
" SU		29	99	19	8.9	5.8	24	2.9		36			12	3.7	22
" %		3.0	2.5	2.3	1.4	1.2	2.4	0.4		1.8			1.1	0.2	0.
GREENS															
Coccoid No.	170	110	86	31	12	4.8	9.6	14	4.8	14	9.6		170	510	310
" SU	28	30	50	3.4	1.2	2.9	3.4	1.4	0.5	1.4	2.9		17	51	31
" %	13.1	9.2	11.2	4.2	0.7	0.6	0.8	1.3	2.8	2.6	3.7		19.1	17.6	12.9
Filamentous No.	4.8	19	2.4		2.4			4.8			4.8			14	
" SU	130	42	1.3		140			16			4.8			23	
" %	0.4	1.0	0.3		0.1			0.4			1.8				
FLAGELLATES															
Pigmented No.	24	12	14	2.4	14	4.8	14	4.8					19	14	14
" SU	2.9	12	12		14	1.0	7.2	4.8					15	16	6.0
" %	1.8	1.0	1.8	0.3	0.8	0.6	1.2	0.4					2.1	0.5	0.7
Unpigmented No.		2.4													
" SU		2.4													
" %		0.2													
DIATOMS															
Centric No.	34	99	120	130	96	34	96	120	14	86	29		43	120	97
" SU	34	120	130	160	110	31	70	110	3.8	33	10		22	130	100
" %	2.6	8.3	15.6	17.6	5.3	4.5	8.0	10.9	8.2	15.9	11.1		4.8	4.1	4.0
Pennate No.	1100	890	510	560	1600	710	1000	940	150	430	220		640	2200	2000
" SU	520	440	180	180	350	210	300	320	29	98	67		220	790	620
" %	84.7	74.2	66.3	76.8	89.0	92.3	83.4	85.4	88.3	79.6	84.7		71.9	75.9	83.1
PROTOZOA															
Sarcodina No.		2.4	2.4												
" SU		14	9.6												
" %		0.2	0.3												
Ciliates No.		14					14	4.8		4.8			4.8		
" SU		32					19	7.2		2.4			9.1		
" %		1.2					1.2	0.4		0.9			0.6		
ROTIFERS No.			2.4												
" SU			7.2												
" %			0.3												
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.															
" SU															
" %															

STATION NO. 11

Location: Vina Bridge — River Mile: 217.6

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
	1960									1961					
TOTAL PLANKTON Number/ml	1300	1200	870	730	950	1000	1200	1200	110		250				
Standard Areal Units/ml	570	800	540	290	380	410	510	470	70		140				
DOMINANT FORMS[1]	10	10	10	10	10	10	10	10	10						
BLUE GREENS															
Coccoid No.[2]	24		2.4		4.8										
" SU[3]	58		0.5		11										
" %[4]	1.8		0.3		0.5										
Filamentous No.	9.6	9.6		7.2	24	9.6	14	19							
" SU	13	5.3		3.1	17	9.1	8.6	15							
" %	0.7	0.8		1.0	2.5	1.0	1.2	1.6							
GREENS															
Coccoid No.	190	140	79	34	19	24	4.8	9.6	4.8		4.8				
" SU	21	39	17	7.0	11	3.4	2.4	4.8	0.5		1.0				
" %	14.6	11.7	9.1	4.7	2.0	2.4	0.4	0.8	4.4		1.9				
Filamentous No.	4.8	22	2.4												
" SU	1.9	100	18												
" %	0.4	1.8	0.3												
FLAGELLATES															
Pigmented No.	58	9.6	4.8	14	19	9.6	4.8	9.6							
" SU	12	11	33	7.0	8.6	2.4	5.8	9.6							
" %	4.5	0.8	0.6	1.9	2.0	1.0	0.4	0.8							
Unpigmented No.		2.4													
" SU		0.5													
" %		0.2													
DIATOMS															
Centric No.	9.6	110	150	120	100	62	100	140	14		53				
" SU	6.7	160	180	120	110	74	100	100	12		21				
" %	0.7	9.2	17.2	16.4	10.5	6.2	8.3	11.7	12.7		21.2				
Pennate No.	960	910	630	550	780	940	1100	1000	86		190				
" SU	500	490	250	150	220	320	360	340	28		120				
" %	73.8	75.8	72.4	75.4	82.2	94.0	91.7	83.4	78.1		76.0				
PROTOZOA															
Sarcodina No.	4.8	31													
" SU	19	78													
" %	0.4	2.6													
Ciliates No.		2.4					24		9.6						
" SU		23					29		29						
" %		0.2					2.0		8.7						
ROTIFERS No.															
" SU															
" %															
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.	0.2														
" SU	3.1														
" %															

STATION NO. 12

Location: Hamilton City Bridge — River Mile: 199.6

	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
	1960									1961					
TOTAL PLANKTON Number/ml	950	1100	1000	980	770	1700	1700	1300				490		3700	
Standard Areal Units/ml	470	630	570	430	310	500	620	640				220		1200	
DOMINANT FORMS[1]	10	10	10	10	10	10	10	10				10		10	
BLUE GREENS															
Coccoid No.[2]	19	2.4	24												
" SU[3]	2.4	0.5	2.4												
" %[4]	2.0	0.2	2.4												
Filamentous No.	9.6	26	7.2	7.2		4.8	9.6	24						4.6	
" SU	32	28	3.6	4.8		9.2	5.3	32						10	
" %	1.0	2.4	0.7	0.7		0.3	0.6	1.8						0.1	
GREENS															
Coccoid No.	130	140	55	58	19	24	24	14				29		730	
" SU	13	20	7.4	14	3.4	2.9	5.8	9.6				2.9		73	
" %	13.7	12.7	5.5	5.9	2.5	1.4	1.4	1.1				5.9		19.7	
Filamentous No.	4.8	29										4.8			
" SU	36	62										24			
" %	0.5	2.9										1.0			
FLAGELLATES															
Pigmented No.	58	9.6	19	2.4	29	4.8	4.8	4.8						4.6	
" SU	12	13	4.3	7.2	18	4.8	5.6	1.9						1.4	
" %	6.1	0.9	1.9	0.2	3.8	0.3	0.3	0.4						0.1	
Unpigmented No.															
" SU															
" %															
DIATOMS															
Centric No.	38	94	210	140	91	77	140	100				77		160	
" SU	35	110	260	130	110	87	110	130				49		160	
" %	4.0	8.6	21.0	14.3	11.8	4.5	8.2	7.7				15.7		4.3	
Pennate No.	690	790	700	770	630	1600	1500	1100				380		2800	
" SU	340	350	290	250	180	400	460	330				120		910	
" %	72.7	71.8	70.0	78.5	81.8	94.2	88.3	84.6				77.5		75.7	
PROTOZOA															
Sarcodina No.		24													
" SU		47													
" %		2.2													
Ciliates No.								4.8							
" SU								19							
" %								0.4							
ROTIFERS No.	0.2														
" SU	3.1														
" %															
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.							4.8	4.8							
" SU	0.1						30	9.6							
" %							0.3	0.4							

1 See code at end of table for identification.
2 Number of plankton in given group/ml.
3 SU = Standard Areal Units/ml.
4 % = Number of plankton/ml in given group as percent of total plankton/ml.

TABLE T-2 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

PLANKTON SURVEY DATA

1960–1961

STATION NO. 13

Location: Ord Ferry — River Mile: 184.5

	1960 April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1961 Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	1200	970	1600	1200	1100	1800	1900	2000						5400	
Standard Areal Units/ml	550	680	790	570	400	600	660	760						1700	
DOMINANT FORMS[1]	10	10	10	10	10	10	10	10						10	
BLUE GREENS															
Coccoid No.[2]	9.8			2.4	4.8										
" SU[3]	26			0.5	9.6										
" %[4]	0.8			0.2	0.4										
Filamentous No.	14	9.6		12		19	19							74	
" SU	14	4.1		8.9		17	19							40	
" %	1.2	1.0		1.0		1.0	1.0							1.4	
GREENS															
Coccoid No.	280	55	150	72	38	77	38	24						880	
" SU	28	8.4	20	9.1	13	7.7	10	8.2						88	
" %	23.3	5.7	9.4	6.0	3.4	4.3	2.0	1.2						16.3	
Filamentous No.		14		2.4				4.8						9.2	
" SU		28		22				7.2						23	
" %		1.4		0.2				0.2						0.2	
FLAGELLATES															
Pigmented No.	38	2.4	62	7.2	24		4.8	14							
" SU	10	6.0	28	1.4	5.8		1.4	7.7							
" %	3.2	0.3	3.9	0.6	2.2		0.3	0.7							
Unpigmented No.														9.2	
" SU														14	
" %														0.2	
DIATOMS															
Centric No.	14	120	300	240	96	110	160	140						240	
" SU	11	140	340	190	120	120	140	130						210	
" %	1.2	12.4	18.8	20.0	8.7	6.1	8.4	7.0						4.5	
Pennate No.	830	750	1100	900	880	1600	1600	1800						4200	
" SU	440	360	400	310	250	440	450	610						1300	
" %	69.2	77.3	68.8	75.0	80.0	89.2	84.3	90.0						77.8	
PROTOZOA															
Sarcodina No.	4.8	14			9.6										
" SU	14	40			12										
" %	0.4	1.4			0.9										
Ciliates No.		7.2		2.4			34								
" SU		96		24			44								
" %		0.7		0.2			1.9								
ROTIFERS No.															
" SU															
" %															
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.	0.2														
" SU	8.6														
" %															

STATION NO. 14

Location: Butte City Bridge — River Mile: 168.2

	1960 April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1961 Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	1600	890	1000	1500	1400	2200	2100	2400		720		500		5000	
Standard Areal Units/ml	760	610	620	630	610	800	870	970		280		210		3600	
DOMINANT FORMS[1]	10	10	10	10	10	10	10	10		10		10		10	
BLUE GREENS															
Coccoid No.[2]															
" SU[3]															
" %[4]															
Filamentous No.		24	4.8		19	19	19	19							
" SU		0.7	1.9		12	14	16	2.9							
" %		0.3	0.5		1.4	0.9	0.9	0.8							
GREENS															
Coccoid No.	240	120	50	100	34	29	24	96		24		19		940	
" SU	36	47	8.9	12	8.2	22	2.9	58		61		2.0		100	
" %	15.0	13.5	5.0	6.7	2.4	1.3	1.1	0.4		3.3		3.8		18.8	
Filamentous No.		7.2	2.4											9.2	
" SU		19	2.2											2100	
" %		0.8	0.2											0.4	
FLAGELLATES															
Pigmented No.	110	2.4	2.4	48	19	9.6	14	29		14		4.8		18	
" SU	36	2.9	0.7	22	7.2	2.9	9.1	7.7		9.1		1.0		4.6	
" %	6.9	0.3	0.2	3.2	1.4	0.4	0.7	1.2		1.9		1.0		0.3	
Unpigmented No.														9.2	
" SU														6.4	
" %														0.2	
DIATOMS															
Centric No.	14	120	230	200	200	250	130	150		86		62		140	
" SU	11	160	280	230	230	240	150	170		51		45		190	
" %	0.9	13.5	23.0	13.3	14.3	11.4	6.2	6.2		11.9		12.4		2.8	
Pennate No.	1200	630	750	1200	1100	1900	1900	2200		600		410		3900	
" SU	630	340	330	370	350	510	660	770		160		160		1200	
" %	75.1	70.8	75.0	80.0	78.7	86.5	90.5	91.8		83.3		82.0		78.0	
PROTOZOA															
Sarcodina No.		9.6													
" SU		42													
" %		1.1													
Ciliates No.								9.6							
" SU								9.6							
" %								0.4							
ROTIFERS No.							4.8								
" SU							34								
" %							0.2								
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.	4.8	2.4													
" SU	51	2.9													
" %	0.3	0.3													

STATION NO. 15

Location: Colusa Bridge — River Mile: 144.1

	1960 April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1961 Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	1400	870	2000	2300	2000	2500	2700	2100	590				730		6700
Standard Areal Units/ml	650	640	1100	980	980	1000	860	800	330				310		1700
DOMINANT FORMS[1]	10	10	10	10	10	10	10	10	10				10,20		10
BLUE GREENS															
Coccoid No.[2]	38		4.8												
" SU[3]	2.9		0.5												
" %[4]	2.7		0.3												
Filamentous No.					9.6	9.6	9.6	9.6							
" SU					5.8	4.8	2.9	12							
" %					0.5	0.4	0.4	0.5							
GREENS															
Coccoid No.	420	170	230	312	130	67	38	19	19				210		1600
" SU	44	43	35	56	17	92	8.6	1.9	1.9				22		170
" %	30.0	19.6	11.5	13.6	6.5	2.7	1.4	0.9	3.2				28.8		23.9
Filamentous No.			4.8		4.8										
" SU			7.2		79										
" %			0.3		0.3										
FLAGELLATES															
Pigmented No.	86	2.4	43	53	38	4.8	9.6	9.6	19				19		74
" SU	12	9.9	21	37	15	12	2.9	2.9	19				11		22
" %	6.1	0.3	2.1	2.3	1.9	1.9	0.4	0.5	3.2				2.6		1.1
Unpigmented No.															
" SU															
" %															
DIATOMS															
Centric No.	53	110	350	440	290	510	210	160	29				19		430
" SU	65	150	430	350	380	430	160	100	18				13		310
" %	3.8	12.7	17.5	19.1	14.5	20.4	7.8	7.6	4.9				2.6		6.4
Pennate No.	840	580	1400	1500	1500	1900	2400	1900	500				480		4600
" SU	480	420	580	540	560	450	670	680	280				260		1200
" %	60.0	66.7	70.0	65.3	75.0	76.0	89.0	90.5	84.7				65.8		68.7
PROTOZOA															
Sarcodina No.															
" SU															
" %															
Ciliates No.		4.8					9.6		19				4.8		
" SU		13					14		16				7.2		
" %		0.6					0.4		3.2				0.7		
ROTIFERS No.	4.8														
" SU	43														
" %	0.3														
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.			4.8												
" SU			27												
" %			0.3												

STATION NO. 16

Location: Below Wilkins Slough — River Mile: 118.1

	1960 April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1961 Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml	1400	650	1700	2100	1600	2500	2500	2600		590		490		5400	
Standard Areal Units/ml	600	650	820	840	690	880	1100	930		310		250		1400	
DOMINANT FORMS[1]	10	10	10	10	10	10	10	10		10		10		10	
BLUE GREENS															
Coccoid No.[2]	19					9.6									
" SU[3]	5.8					1.0									
" %[4]	1.4					0.4									
Filamentous No.						9.6		9.6		4.8				9.2	
" SU						25		7.7		2.4				7.4	
" %						0.4		0.4		0.8				0.2	
GREENS															
Coccoid No.	460	65	260	290	130	240	48	96		53		19		2000	
" SU	58	31	58	30	22	47	12	46		7.2		2.0		200	
" %	32.9	10.0	15.3	13.8	8.1	9.6	1.9	3.7		9.0		3.9		37.1	
Filamentous No.	4.8	4.8													
" SU	2.4	7.2													
" %	0.3	0.7													
FLAGELLATES															
Pigmented No.	190	2.4	76	43	34	130		19		24				55	
" SU	72	2.4	20	15	15	60		4.8		24				26	
" %	13.6	0.4	4.5	2.0	2.1	5.2		0.7		4.1				1.0	
Unpigmented No.														9.2	
" SU														37	
" %														0.2	
DIATOMS															
Centric No.	14	98	240	340	230	450	390	230		67		58		250	
" SU	62	120	300	290	260	230	370	250		38		40		190	
" %	1.0	15.1	14.1	16.2	14.4	18.0	15.6	8.9		11.3		11.8		4.6	
Pennate No.	710	470	1100	1400	1200	1700	2100	2200		430		410		3100	
" SU	380	420	440	500	390	520	720	620		[illegible]		200		910	
" %	50.7	72.3	64.8	66.8	75.0	68.0	84.0	84.7		72.7		83.8		57.3	
PROTOZOA															
Sarcodina No.	4.8											4.8			
" SU	5.8											7.2			
" %	0.3											1.0			
Ciliates No.	4.8	7.2					9.6			14					
" SU	12	65					12			12					
" %	0.3	1.1					0.4			2.4					
ROTIFERS No.															
" SU															
" %															
CRUSTACEA No.															
" SU															
" %															
NEMATODES No.															
" SU															
" %															

1 See code at end of table for identification.
2 Number of plankton in given group/ml.
3 SU = Standard Areal Units/ml.
4 % = Number of plankton/ml in given group as percent of total plankton/ml.

TABLE T-2 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

PLANKTON SURVEY DATA

1960-1961

STATION NO 17

Location: Above Colusa Basin Drain — River Mile: 90.5

		1960 April	1960 May	1960 June	1960 July	1960 Aug.	1960 Sept.	1960 Oct.	1960 Nov.	1960 Dec.	1961 Jan.	1961 Feb.	1961 March	1961 April	1961 May	1961 June
TOTAL PLANKTON	Number/ml	1600	940	1400	2600	2000	2700	2600	2100	610		330		950	6300	7800
	Standard Areal Units/ml	580	870	870	1000	1200	1000	1100	1000	370		270		350	1300	1600
DOMINANT FORMS[1]		20	10	10	10	10	10	10	10	10				10,20	20	20
BLUE GREENS																
Coccoid	No.[2]	14	4.8													
"	SU[3]	1.0	4.8													
"	%[4]	0.9	0.5													
Filamentous	No.	4.8	19					9.6							9.2	9.2
"	SU	5.8	86					3.8							4.6	3.7
"	%	0.3	2.0					0.4							0.2	0.1
GREENS																
Coccoid	No.	570	280	150	470	330	160	77	9.6	9.6				260	3400	3800
"	SU	58	53	34	60	350	22	27	1.0	7.7				26	350	400
"	%	35.3	29.8	10.7	18.1	16.5	5.9	3.0	0.5	1.6				27.4	56.7	48.7
Filamentous	No.	4.8												4.8		
"	SU	5.3												6.2		
"	%	0.3												0.5		
FLAGELLATES																
Pigmented	No.	140	19	72	86	48	86	77	19			9.6		4.8	55	37
"	SU	43	28	15	46	22	36	40	5.8			7.7		1.4	18	29
"	%	8.7	2.0	5.1	3.3	2.4	3.2	3.0	0.9			2.9		0.5	0.5	0.5
Unpigmented	No.														9.2	
"	SU														41	
"	%														0.2	
DIATOMS																
Centric	No.	48	82	270	360	230	600	480	220	58		29		130	300	750
"	SU	85	100	310	310	380	360	330	120	47		14		77	140	340
"	%	3.0	8.7	19.3	13.8	11.5	22.2	18.5	10.5	9.5		8.8		13.7	5.0	9.6
Pennate	No.	790	530	920	1700	1400	1900	2000	1900	530		290		550	2500	3200
"	SU	360	480	510	620	410	580	740	910	300		250		240	770	1000
"	%	49.4	56.5	65.7	65.5	70.0	70.4	76.9	90.3	87.0		87.9		57.9	41.7	41.0
PROTOZOA																
Sarcodina	No.	9.6	4.8													
"	SU	14	24													
"	%	0.6	0.5													
Ciliates	No.	4.8								9.6						
"	SU	11								14						
"	%	0.3								1.6						
ROTIFERS	No.															
"	SU															
"	%															
CRUSTACEA	No.															
"	SU															
"	%															
NEMATODES	No.		4.8													
"	SU		96													
"	%		0.5													

STATION NO.19

Location: Above Sacramento Slough — River Mile: 81.[illegible]

		1960 April	1960 May	1960 June	1960 July	1960 Aug.	1960 Sept.	1960 Oct.	1960 Nov.	1960 Dec.	1961 Jan.	1961 Feb.	1961 March	1961 April	1961 May	1961 Ju[ne]
TOTAL PLANKTON	Number/ml	1500	610	1100	2100	2300	2700	2300	2300	330	680		430		4400	
	Standard Areal Units/ml	640	500	950	950	1300	920	1000	760	160	380		290		2200	
DOMINANT FORMS[1]		20	10	10	10	10	10	10	10	10	10		10		20,10	
BLUE GREENS																
Coccoid	No.[2]			4.8			9.6									
"	SU[3]			7.2			1.9									
"	%[4]			0.4			0.4									
Filamentous	No.	4.8	9.6		9.6		9.6	9.6	9.6		48				46	
"	SU	48	1.9		42		2.9	36	9.6		9.1				23	
"	%	0.3	1.6		0.5		0.4	0.4	0.4		0.7				1.0	
GREENS																
Coccoid	No.	740	210	110	450	320	220	110	120		4.8		14		1900	
"	SU	210	83	58	57	230	50	24	20		.5		1.4		200	
"	%	49.3	34.5	10.0	21.4	13.9	8.2	4.8	5.2		0.7		3.3		43.2	
Filamentous	No.		1.0												9.2	
"	SU		19												830.	
"	%		0.2													
FLAGELLATES																
Pigmented	No.	120	14	67	38	96	48	86	29	48	38				100	
"	SU	52	28	26	12	45	26	88	12	43	42				47	
"	%	18.0	2.3	6.1	1.8	4.2	1.8	3.7	1.3	14.6	5.6				2.3	
Unpigmented	No.															
"	SU															
"	%															
DIATOMS																
Centric	No.	34	58	300	390	500	970	500	220	58	210		86		400	
"	SU	54	97	390	350	420	450	260	110	36	78		60		210	
"	%	2.3	9.5	27.3	18.6	21.7	35.9	21.7	9.6	17.6	30.9		20.0		9.1	
Pennate	No.	600	310	670	1200	1400	1400	1600	1900	220	420		330		1900	
"	SU	230	250	470	490	600	440	580	610	79	250		230		890	
"	%	40.0	50.9	61.1	57.2	60.9	51.8	69.6	82.6	66.8	61.8		76.8		43.2	
PROTOZOA																
Sarcodina	No.	4.8														
"	SU	10														
"	%	0.3														
Ciliates	No.	9.6	48					19								
"	SU	36	24					32								
"	%	0.6	7.9					0.8								
ROTIFERS	No.															
"	SU															
"	%															
CRUSTACEA	No.															
"	SU															
"	%															
NEMATODES	No.															
"	SU															
"	%															

STATION NO.20

Location: Bryte Laboratory — River Mile: 62.6

		1960 April	1960 May	1960 June	1960 July	1960 Aug.	1960 Sept.	1960 Oct.	1960 Nov.	1960 Dec.	1961 Jan.	1961 Feb.	1961 March	1961 April	1961 May	1961 June
TOTAL PLANKTON	Number/ml	1000	650	1200	2500	2300	3000	2600	2600	550	1200	390	620	960	3600	8300
	Standard Areal Units/ml	430	780	720	1000	1200	2100	1600	2200	1000	610	460	380	620	1400	2400
DOMINANT FORMS[1]		10	10	10	30	10	10, 17, 30	10, 17	10, 17	17	10, 31		10	10, 31, 20	20, 10	31
BLUE GREENS																
Coccoid	No.[2]	19		14	29	9.6										9.2
"	SU[3]	3.8		8.2	3.8	2.9										0.9
"	%[4]	1.9		1.2	1.2	0.4										0.1
Filamentous	No.	9.6	14	9.6			9.6	19	9.6	9.6				4.8	18	9.2
"	SU	24	35	16			24	19	30	8.2				2.4	28	1.8
"	%	1.0	2.2	0.8			0.3	0.7	0.4	1.7				0.8	0.5	0.1
GREENS																
Coccoid	No.	390	140	300	730	280	270	120	29		96	19	24	120	1300	2800
"	SU	43	59	61	98	58	47	18	17		24	19	2.4	13	170	420
"	%	39.0	21.5	25.0	29.2	12.2	9.0	4.6	1.1		8.0	4.9	3.9	12.5	37.6	33.7
Filamentous	No.		4.8											9.6		
"	SU		11											46		
"	%		0.6											1.6		
FLAGELLATES																
Pigmented	No.	14	10	130	120	96	77	110	67		100		14	4.8	140	200
"	SU	27	34	60	82	50	73	57	63		63		9.1	1.9	100	78
"	%	1.4	1.5	10.8	4.8	4.2	2.6	4.2	2.6		8.3		2.3	0.8	4.1	2.4
Unpigmented	No.															
"	SU															
"	%															
DIATOMS																
Centric	No.		86	190	640	660	1000	600	350	34	360	77	120	190	410	3100
"	SU		110	210	460	460	550	340	400	56	150	35	66	86	200	960
"	%		13.2	15.8	25.6	28.7	33.3	23.1	13.5	6.2	30.0	19.8	19.4	19.8	11.9	37.4
Pennate	No.	610	380	560	1000	1200	1600	1700	2100	500	630	290	460	630	1700	2200
"	SU	330	370	360	400	550	1400	1200	1700	980	360	410	300	470	860	880
"	%	61.0	58.5	46.6	40.0	52.2	53.3	65.3	80.7	90.8	52.5	74.3	74.2	65.6	49.2	26.5
PROTOZOA																
Sarcodina	No.		4.8													
"	SU		29													
"	%		0.6													
Ciliates	No.		4.8	4.8		9.6		19		4.8	9.6					18
"	SU		92	7.2		14		12		3.8	7.2					23
"	%		0.6	0.4		0.4		0.7		0.9	0.8					0.2
ROTIFERS	No.		4.8			9.6										
"	SU		36			43										
"	%		0.6			0.4										
CRUSTACEA	No.															
"	SU															
"	%															
NEMATODES	No.										4.8					
"	SU										7.2					
"	%										0.4					

STATION NO.22

Location: Freeport Bridge — River Mile: 46.4

		1960 April	1960 May	1960 June	1960 July	1960 Aug.	1960 Sept.	1960 Oct.	1960 Nov.	1960 Dec.	1961 Jan.	1961 Feb.	1961 March	1961 April	1961 May	1961 June
TOTAL PLANKTON	Number/ml	1700	790	1500	1800	2000	3800	2400	2300	680	710	360	520	680	4600	[illegible]
	Standard Areal Units/ml	640	570	780	880	930	2500	1800	2400	1200	340	190	370	560	1500	[illegible]
DOMINANT FORMS[1]		20	10	10	30	31	31 17,30	17	10,17	17,30	31		10	10,31	20	[illegible]
BLUE GREENS																
Coccoid	No.[2]	86			19	9.6	9.6									[illegible]
"	SU[3]	16			2.4	5.3	19									[illegible]
"	%[4]	5.1			1.1	0.5	0.3									[illegible]
Filamentous	No.		14		4.8		19		19							[illegible]
"	SU		5.3		1.4		100		9.6							[illegible]
"	%		1.8		0.3		0.5		0.8							[illegible]
GREENS																
Coccoid	No.	810	290	390	500	210	77	170	110	9.6	91	29	4.8	82	2100	[illegible]
"	SU	92	110	70	84	31	110	87	17	2.4	13	2.9	.5	19	250	[illegible]
"	%	47.6	36.7	26.0	27.8	10.5	2.0	7.1	4.8	1.4	12.8	8.0	0.9	9.3	45.7	[illegible]
Filamentous	No.		4.8													
"	SU		4.8													
"	%		0.6													
FLAGELLATES																
Pigmented	No.	86	14	240	110	120	180	58	29	14	91	9.6	9.6	34	9.2	[illegible]
"	SU	98	41	72	56	47	140	99	19	21	40	1.9	3.4	22	5.6	[illegible]
"	%	5.1	1.8	16.0	6.1	6.0	4.7	2.4	1.3	2.1	12.8	2.7	1.8	3.9	0.2	[illegible]
Unpigmented	No.								9.6	4.8						
"	SU								14	7.2						
"	%								0.4	0.7						
DIATOMS																
Centric	No.	72	77	240	530	820	2000	680	580	220	150	96	100	250	750	[illegible]
"	SU	81	110	290	260	390	1000	340	1000	340	81	47	40	110	250	[illegible]
"	%	4.2	9.9	16.0	29.4	41.0	52.7	28.3	25.2	32.3	21.1	26.7	18.2	28.4	16.3	[illegible]
Pennate	No.	680	380	630	610	870	1500	1500	1600	420	360	230	400	510	1600	[illegible]
"	SU	250	270	320	470	430	1100	1100	1300	760	190	140	300	380	850	[illegible]
"	%	39.4	48.2	42.0	33.4	43.5	39.5	62.5	69.6	61.7	50.7	63.9	76.9	58.0	34.7	[illegible]
PROTOZOA																
Sarcodina	No.	4.8		4.8												
"	SU	6.2		18												
"	%	0.3		0.3												
Ciliates	No.	4.8	4.8	9.6	4.8	4.8	48		9.6	9.6	14		9.6	4.8	9.2	[illegible]
"	SU	7.2	19	9.1	4.8	7.2	53		7.7	26	14		22	24	9.2	43
"	%	0.3	0.6	0.6	0.3	0.3	1.3		0.4	1.4	2.0		1.8	0.5	0.2	0.4
ROTIFERS	No.	4.8	0.5													
"	SU	90	6.1													
"	%	0.3														
CRUSTACEA	No.															
"	SU															
"	%															
NEMATODES	No.															
"	SU															
"	%															

1 See code at end of table for identification.
2 Number of plankton in given group/ml.
3 SU = Standard Areal Units/ml.
4 % = Number of plankton/ml in given group as percent of total plankton/ml.

TABLE T-2 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

PLANKTON SURVEY DATA

1960–1961

STATION NO. 23

Location: Above Clarksburg — River Mile: 43.4

		1960									1961					
		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml		1400	830	1300	2300	3500	3200	1900	2100						3700	
Standard Areal Units/ml		520	510	510	1100	1400	1400	1600	2700						960	
DOMINANT FORMS[1]		21	10	20,21	30	31	31 17,30	31,17	10 17,30						20,10	
BLUE GREENS Coccoid	No.[2]	29			4.8	29										
"	SU[3]	3.8			2.4	2.9										
"	%[4]	2.1			0.2	0.8										
Filamentous	No.		14	9.6	4.8		9.6	9.6							9.2	
"	SU		13	26	5.7		2.9	9.6							2.8	
"	%		1.7	0.7	0.2		0.3	0.5							0.2	
GREENS Coccoid	No.	720	310	550	610	460	400	140	67						1400	
"	SU	100	84	72	78	88	77	23	16						150	
"	%	51.4	37.4	42.3	26.5	13.1	12.5	7.4	3.2						37.9	
Filamentous	No.															
"	SU															
"	%															
FLAGELLATES Pigmented	No.	48	14	110	82	230	130	9.6	77						55	
"	SU	46	25	33	43	140	120	14	39						18	
"	%	3.4	1.7	8.5	3.6	6.6	4.1	0.5	3.7						1.5	
Unpigmented	No.	4.8						9.6								
"	SU	7.2						60								
"	%	0.3						0.5								
DIATOMS Centric	No.	38	67	150	780	1400	1400	570	480						760	
"	SU	110	68	130	540	620	530	500	540						230	
"	%	2.7	8.1	11.5	33.9	40.0	43.8	30.0	22.9						20.5	
Pennate	No.	510	410	430	800	1400	1300	1200	1500						1500	
"	SU	240	290	240	420	420	720	950	2100						550	
"	%	36.5	49.5	33.1	34.8	40.0	40.6	63.2	71.4						40.6	
PROTOZOA Sarcodina	No.	9.6	14													
"	SU	17	26													
"	%	0.7	1.7													
Ciliates	No.			4.8		9.6		9.6							9.2	
"	SU			7.2		14		12							14	
"	%			0.4		0.3		0.5							0.2	
ROTIFERS	No.		0.5			9.6										
"	SU		3.0			96										
"	%					0.3										
CRUSTACEA	No.															
"	SU															
"	%															
NEMATODES	No.															
"	SU															
"	%															

STATION NO. 24

Location: Snodgrass Slough — River Mile: 37.2

		1960									1961					
		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml		1300	900	1600	2200	3900	4100	3300	2500	550	780	240	640	1300	3500	8700
Standard Areal Units/ml		460	560	870	940	1400	2500	1800	2300	650	340	100	410	450	1200	2300
DOMINANT FORMS[1]		10,20	20,27	10,20	31	31	31	31,17	17,30	17	31		10,21	31,10	20,10	31
BLUE GREENS Coccoid	No.[2]	62		4.8	14			9.6								37
"	SU[3]	10		0.5	6.2			3.8								5.5
"	%[4]	4.8		0.3	0.6			0.4								0.4
Filamentous	No.		14		4.8	9.6		9.6	38				4.8			18
"	SU		48		1.4	96		7.7	35				4.8			11
"	%		1.5		0.2	0.2		0.4	1.5				0.8			0.2
GREENS Coccoid	No.	560	440	520	480	470	300	190	38	14	38	19	43	220	1100	2000
"	SU	68	99	100	82	92	130	43	3.8	4.8	10	1.9	13	27	140	340
"	%	43.1	48.9	32.5	21.8	12.1	7.3	8.3	1.5	2.5	4.9	7.9	6.7	16.9	31.3	23.0
Filamentous	No.		4.8			9.6										
"	SU		3.8			17										
"	%		0.5			0.2										
FLAGELLATES Pigmented	No.	24	43	170	48	67	240	19		14	67	29	9.6	48	37	170
"	SU	24	61	77	34	35	190	3.8		15	43	26	3.4	29	26	76
"	%	1.8	4.8	10.6	2.2	1.7	5.9	0.8		2.5	8.6	12.1	1.5	3.7	1.1	1.9
Unpigmented	No.															
"	SU															
"	%															
DIATOMS Centric	No.	58	29	340	940	1500	2400	690	730	240	210	19	180	480	590	4100
"	SU	85	34	310	400	620	1000	590	1200	230	92	48	69	180	410	1100
"	%	4.5	3.2	21.3	42.7	38.5	58.6	30.0	29.2	43.7	26.9	7.9	[illegible]	36.9	16.9	47.2
Pennate	No.	570	360	530	720	1600	1100	1400	1600	280	460	170	400	510	1700	2400
"	SU	190	290	380	410	520	890	1200	1000	400	190	72	320	210	620	770
"	%	43.8	40.0	33.1	32.7	46.2	26.9	60.8	64.1	50.9	59.0	70.8	62.4	39.2	48.6	27.6
PROTOZOA Sarcodina	No.		4.8													
"	SU		14													
"	%		0.5													
Ciliates	No.	9.6	4.8	4.8	48		38							4.8	37	9.2
"	SU	11	4.8	7.2	4.8		270							6.2	3.7	9.2
"	%	0.7	0.5	0.3	0.2		0.9							0.4	1.1	0.1
ROTIFERS	No.		0.5			9.6										
"	SU		3.1			29										
"	%					0.2										
CRUSTACEA	No.	9.6														
"	SU	77														
"	%	0.7														
NEMATODES	No.		0.2													
"	SU		5.5													
"	%															

STATION NO. 25

Location: Above Delta Cross Channel — River Mile: 27.4

		1960									1961					
		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml		1500	810	1900	2600	3500	4300	3200	2500		690		320		3600	
Standard Areal Units/ml		430	660	910	540	1400	2400	2300	2600		330		330		1400	
DOMINANT FORMS[1]		20	20	30	31	31	31	31,17	17,30		31		10		20,10	
BLUE GREENS Coccoid	No.[2]	19	14	24	39	9.6										
"	SU[3]	4.3	1.9	7.7	5.8	19										
"	%[4]	1.3	1.7	1.3	1.5	0.3										
Filamentous	No.		14			9.6		9.6								
"	SU		7.2			11		15								
"	%		1.7			0.3		0.3								
GREENS Coccoid	No.	940	370	530	320	380	330	130	150		120				1200	
"	SU	120	81	160	48	61	55	41	40		17				200	
"	%	62.7	45.7	27.9	12.3	10.9	7.7	4.1	6.0		17.4				33.3	
Filamentous	No.	4.8	9.6												9.2	
"	SU	3.3	28												60	
"	%	0.3	1.2												0.3	
FLAGELLATES Pigmented	No.	9.6	24	170	53	130	160	48	96		38		9.6		140	
"	SU	6.2	56	56	35	100	160	27	85		27		12		110	
"	%	0.6	3.0	8.9	2.0	3.7	3.7	1.5	3.8		5.5		3.0		3.9	
Unpigmented	No.															
"	SU															
"	%															
DIATOMS Centric	No.	53	24	600	1600	1400	2700	1400	720		200		67		780	
"	SU	59	39	420	80	590	980	770	1200		100		36		270	
"	%	3.5	3.0	31.5	61.6	40.0	62.8	43.7	28.8		29.0		20.9		21.7	
Pennate	No.	460	350	520	610	1600	1100	1600	1500		330		240		1400	
"	SU	180	400	260	320	580	1200	1400	1300		180		280		630	
"	%	30.7	43.2	27.3	23.5	45.7	25.6	50.0	60.0		47.8		75.2		38.9	
PROTOZOA Sarcodina	No.															
"	SU															
"	%															
Ciliates	No.	9.6	4.8	9.6	4.8	19		19			4.8				37	
"	SU	13	7.2	11	7.2	29		7.6			4.8				42	
"	%	0.6	0.6	0.5	0.2	0.5		0.6			0.7				1.0	
ROTIFERS	No.	4.8														
"	SU	42														
"	%	0.3														
CRUSTACEA	No.				4.8											
"	SU		39		4.8											
"	%				0.2											
NEMATODES	No.															
"	SU															
"	%															

STATION NO. 26

Location: Isleton Bridge — River Mile: 18.8

		1960									1961					
		April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml		1200	980	5100	5400	8100	4800	1500	2300	2200	1000	290	740	1500	3300	15,000
Standard Areal Units/ml		420	810	2300	1900	2400	2800	1600	2400	2200	580	390	350	590	1300	4,800
DOMINANT FORMS[1]		20	10	31	31	31	31,17	31,17	30,17	17	31,10		10,31	31	20, 31,10	31
BLUE GREENS Coccoid	No.[2]	34		24		48	9.6									64
"	SU[3]	5.3		9.4		4.8	14									17
"	%[4]	2.8		0.5		0.6	0.2									0.4
Filamentous	No.		14	4.8		29	9.6		19						9.2	55
"	SU		4.8	2.9		25	15		9.6						3.7	140
"	%		1.4	0.1		0.4	0.2		0.8						0.3	0.4
GREENS Coccoid	No.	720	390	800	660	800	210	120	67	58	140	4.8	29	280	850	1,300
"	SU	85	69	140	120	140	49	17	22	17	24	.5	7.2	30	140	430
"	%	60.0	39.8	15.7	12.2	9.9	4.4	8.0	2.9	2.6	14.0	1.7	3.9	18.7	25.7	8.7
Filamentous	No.	4.5	4.8											4.8		
"	SU	9.6	13											6.2		
"	%	0.4	0.5											0.3		
FLAGELLATES Pigmented	No.	29	19	140	160	180	86	9.6	38	29	62	14	36	34	160	260
"	SU	64	38	94	120	150	48	14	27	38	34	12	17	13	93	150
"	%	2.4	1.9	2.8	3.0	2.2	1.8	0.6	1.6	1.3	6.2	4.8	5.1	2.3	4.9	1.7
Unpigmented	No.															
"	SU															
"	%															
DIATOMS Centric	No.	34	82	3400	3600	4700	3300	540	960	360	250	100	180	670	950	9,600
"	SU	40	230	1200	1100	1200	1300	350	1100	240	140	87	48	260	330	2,900
"	%	2.8	8.4	66.7	66.8	58.0	68.8	36.0	41.7	16.4	25.0	34.5	24.3	44.7	28.8	64.0
Pennate	No.	380	450	770	1000	2300	1200	810	1200	1700	560	170	490	520	1300	3,300
"	SU	220	360	830	550	900	1300	1100	1200	1900	380	290	270	270	560	1,000
"	%	31.7	45.9	15.1	18.5	28.4	25.0	54.0	52.2	77.3	56.0	58.6	66.3	34.7	39.4	22.0
PROTOZOA Sarcodina	No.		9.6													
"	SU		24													
"	%		1.0													
Ciliates	No.		9.6		19		19	9.6		9.6	4.8		4.8	9.6	9.2	37
"	SU		33		24		33	130		9.6	4.8		9.6	14	14	180
"	%		1.0		0.4		0.4	0.6		0.4	0.5		0.7	0.6	0.3	0.3
ROTIFERS	No.		0.7		4.8											
"	SU		35		14											
"	%				0.1											
CRUSTACEA	No.															
"	SU		0.2													
"	%															
NEMATODES	No.															
"	SU															
"	%															

1. See code at end of table for identification.
2. Number of plankton in given group/ml.
3. SU = Standard Areal Units/ml.
4. % = Number of plankton/ml in given group as percent of total plankton/ml.

TABLE T-2 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

PLANKTON SURVEY DATA

1960 - 1961

Location: Rio Vista Bridge — STATION NO 27 — River Mile: 12.8

		1960 April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1961 Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml		780	700	8300	5400	6600	5000	3800	2600	1400	1300	240		1200		9600
Standard Areal Units/ml		410	510	3700	2300	2800	3000	3400	2300	2000	680	210		660		4400
DOMINANT FORMS[1]		20	20,21	31	31	31	31	31,17	31 30,17	17	31			31		31
BLUE GREENS Coccoid	No.[2]	29	9.6			38	9.6									4.2
"	SU[3]	4.3	2.9			12	2.9									3.7
"	%[4]	3.7	1.4			0.6	0.2									0.1
Filamentous	No.		4.8	19	19		9.6		19		9.6					28
"	SU		2.4	41	17	4.8			52		24					29
"	%		0.7	0.2	0.4	0.1			0.7		0.7					0.2
GREENS Coccoid	No.	450	320	150	144	230	190	150	110	67	96			110		290
"	SU	90	53	73	172	210	52	89	13	12	12			39		160
"	%	57.7	45.8	1.8	2.7	3.5	3.8	4.0	4.2	4.8	7.4			9.2		3.0
Filamentous	No.	4.8														
"	SU	24														
"	%	0.6														
FLAGELLATES Pigmented	No.	9.6	14	130	110	130	130	120	48	19	58	43		67		37
"	SU	12	33	77	35	61	100	73	35	38	34	37		65		24
"	%	1.2	2.0	1.6	2.0	2.0	2.6	3.2	1.8	1.4	4.5	17.9		5.6		0.4
Unpigmented	No.															
"	SU															
"	%															
DIATOMS Centric	No.	29	100	6700	4600	4400	3400	2200	1400	390	420	72		680		7700
"	SU	78	160	2100	1300	1600	1700	1800	1300	370	180	74		340		3400
"	%	3.7	14.3	80.8	85.3	66.7	68.0	57.9	53.8	27.9	32.3	30.0		56.7		80.3
Pennate	No.	240	240	1300	500	1800	1200	1300	970	920	740	120		380		1500
"	SU	140	200	1400	340	920	1000	1400	880	1600	420	98		220		710
"	%	30.8	34.3	15.7	9.3	27.3	24.0	34.3	37.3	65.8	57.0	50.0		31.7		15.6
PROTOZOA Sarcodina	No.	14				9.6										
"	SU	56				14										
"	%	1.8				0.1										
Ciliates	No.	4.8	4.8		29		29	9.6	19	9.6	9.6					18
"	SU	7.2	34		420		62	18	24	9.6	9.6					58
"	%	0.6	0.7		0.5		0.6	0.3	0.7	0.7	0.7					0.2
ROTIFERS	No.		4.8			0.2	9.6									
"	SU		29			1.9	58									
"	%		0.7				0.2									
CRUSTACEA	No.															
"	SU															
"	%															
NEMATODES	No.															
"	SU															
"	%															

Location: Above Mayberry Slough — STATION NO. 28 — River Mile: 4.0

		1960 April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	1961 Jan.	Feb.	March	April	May	June
TOTAL PLANKTON Number/ml		1000	1300	3700	2900	2800	3600	2200	3700	2000	1400	350	240	910	4900	12,000
Standard Areal Units/ml		900	860	2000	1400	1300	1900	1100	2000	1900	870	270	360	440	1900	4,900
DOMINANT FORMS[1]		20	20	31	31	31	31	31	31	31	31	31	31	31	31	31
BLUE GREENS Coccoid	No.[2]	4.8	72	9.6		29										
"	SU[3]	0.6	20	3.8		5.8										
"	%[4]	0.5	5.5	0.3		1.0										
Filamentous	No.		4.8			9.6		19						4.8		9.2
"	SU		30			11		31						3.8		15
"	%		0.4			0.3		0.9						0.5		0.2
GREENS Coccoid	No.	400	830	170	330	230	86	96	19	86	96	4.8	4.8	96	330	160
"	SU	220	360	71	68	44	38	42	6.7	12	9.6	2.4	.5	22	90	540
"	%	40.0	63.8	4.6	11.4	8.2	2.5	4.4	0.7	4.3	6.9	1.4	0.9	10.5	6.7	1.3
Filamentous	No.															
"	SU															
"	%															
FLAGELLATES Pigmented	No.	413	24	68	290	360	270	96	19	67	19	58	19	58	37	450
"	SU	60	33	30	260	230	200	58	8.6	62	12	48	14	32	24	260
"	%	4.3	1.8	1.8	10.0	12.9	7.5	4.4	0.7	3.4	1.4	16.5	4.3	6.4	0.8	3.7
Unpigmented	No.															
"	SU															
"	%															
DIATOMS Centric	No.	230	180	2500	2000	1900	2600	1500	3000	1200	960	140	220	400	3600	11,000
"	SU	250	160	1100	810	920	1200	700	1600	820	680	110	120	200	1300	3,600
"	%	23.0	13.9	67.6	69.0	68.0	72.3	68.3	81.6	60.0	68.6	40.0	50.0	44.0	73.4	91.8
Pennate	No.	270	150	1000	310	280	620	490	440	660	340	150	200	350	910	700
"	SU	330	170	770	310	99	420	260	390	1000	110	110	230	170	410	470
"	%	27.0	11.5	27.0	11.7	10.0	17.2	22.3	16.3	33.0	24.3	42.8	45.5	38.5	18.6	5.8
PROTOZOA Sarcodina	No.	14														
"	SU	59														
"	%	1.4														
Ciliates	No.		4.8				9.6					9.6			28	9.2
"	SU		38				14					60			26	20
"	%		0.4				0.3					6.9			0.6	0.1
ROTIFERS	No.															
"	SU															
"	%															
CRUSTACEA	No.													.02		
"	SU													16		
"	%															
NEMATODES	No.															
"	SU															
"	%															

1 See code at end of table for identification.
2 Number of plankton is given group/ml.
3 SU = Standard Areal Units/ml.
4 % = Number of plankton/ml in given group as percent of total plankton/ml.

ARBITRARY CODE IDENTIFICATION OF PLANKTERS

Code Numbers	Genus or Genus-type
10	Synedra-type
11	Asterionella
12	Fragilaria
13	Cymbella
17	Tabellaria-type
20	Ankistrodesmus
21	Scenedesmus
27	Actinastrum
30	Melosira
31	Cyclotella-type

TABLE T-3 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF PLANKTON SURVEY

SELECTED PHYSICAL AND CHEMICAL DATA

1960-1961

STATION NO. 16, RIVER MILE 118.1

Month	Total Plankton no/ml	Temp. °F	Flow cfs x 10^{-3}	Velocity ft/sec	BOD (mg/l)	NO_3 (mg/l)	Org.N (mg/l)	PO_4 (mg/l)	SiO_2 (mg/l)	Turbidity (mg/l)	TDS (mg/l)
1960											
April	1400	63	4.6	2.08	1.09	0.4	0.0	0.0	23	2	-
May	650	66	6.2	2.39	0.92	0.5	0.0	0.1	24	4.1	-
June	1700	67	5.1	2.18	0.58	0.6	0.0	0.0	25	55	-
July	2100	67	5.8	2.32	0.66	0.3	0.0	0.1	24	9	-
August	1600	67	5.7	2.30	0.37	0.6	0.1	0.1	24	10	-
September	2500	68	5.5	2.26	0.48	0.3	0.0	-	24	6	100
October	2500	59	5.8	2.32	0.71	0.4	0.2	0.1	25	8	102
November	2600	56	5.5	2.26	1.75	2.3	0.2	0.1	23	50	88
December	-	-	6.5	2.42	2.04	1.2	0.0	0.1	28	13	123
1961											
January	590	48	6.6	2.43	1.60	1.3	0.1	0.1	27	15	122
February	-	-	15.4	3.71	0.89	0.5	0.1	0.1	25	43	91
March	490	51	15.9	3.74	0.82	0.6	0.0	0.1	23	30	93
April	-	-	9.7	2.83	-	-	-	-	-	-	-
May	5400	64	6.1	2.37	1.28	-	-	-	-	-	-
June	-	-	5.1	2.18	-	-	-	-	-	-	-

STATION NO. 17, RIVER MILE 90.5*

Month	Total Plankton no/ml	Temp. °F	Flow cfs x 10^{-3}	Velocity ft/sec	BOD (mg/l)	NO_3 (mg/l)	Org.N (mg/l)	PO_4 (mg/l)	SiO_2 (mg/l)	Turbidity (mg/l)	TDS (mg/l)
1960											
April	1600	-	4.2	1.72	0.77	0.7	0.0	0.1	23	2	-
May	940	68	7.6	2.50	0.98	0.8	0.1	0.1	24	5.3	-
June	1400	68	5.1	1.88	0.72	0.8	0.2	0.1	25	70	-
July	2600	-	6.5	1.97	0.42	0.3	0.1	0.1	24	11	-
August	2000	69	6.3	2.43	0.38	0.4	0.1	0.1	24	10	-
September	2700	67	6.2	2.41	1.20	0.2	0.2	-	24	10	95
October	2600	60	5.6	2.07	0.54	0.6	0.2	0.1	25	6	100
November	2100	56	5.8	2.13	1.32	1.2	0.0	0.1	25	45	90
December	610	47	7.7	2.52	1.10	1.0	0.0	0.2	28	11	130
1961											
January	-	-	7.1	2.40	1.21	0.9	0.1	0.1	27	15	125
February	330	52	13.8	3.49	0.86	0.5	0.0	0.1	25	68	96
March	-	-	16.6	3.71	0.68	0.9	0.0	0.1	24	30	96
April	950	60	9.8	2.85	0.56	-	-	-	-	-	-
May	6300	-	8.0	2.59	-	-	-	-	-	-	-
June	7800	74	5.9	2.15	0.90	-	-	-	-	-	-

*Flow measurements made at river mile 90.0

STATION NO. 20, RIVER MILE 62.6*

Month	Total Plankton no/ml	Temp. °F	Flow cfs x 10^{-3}	Velocity ft/sec	BOD (mg/l)	NO_3 (mg/l)	Org.N (mg/l)	PO_4 (mg/l)	SiO_2 (mg/l)	Turbidity (mg/l)	TDS (mg/l)
1960											
April	1000	60	13.3	-	0.40	0.90	0.0	0.1	18	1	-
May	650	67	15.4	-	0.78	1.1	0.1	0.0	18	15	-
June	1200	72	7.1	-	1.05	0.6	0.2	0.1	24	80	-
July	2500	76	8.0	-	0.55	0.3	0.1	0.1	24	17	-
August	2300	73	8.1	-	0.51	0.8	0.2	0.1	23	7	-
September	3000	68	8.4	-	0.62	0.3	0.2	-	22	35	127
October	2600	60	7.3	-	0.86	0.1	-	0.1	25	12	110
November	2600	52	8.1	-	1.37	0.7	0.1	0.1	23	30	109
December	550	45	12.0	-	1.35	0.8	0.0	0.1	23	14	126
1961											
January	1200	47	10.7	-	1.28	1.2	0.0	0.1	23	15	129
February	390	52	30.1	-	1.14	0.3	0.2	0.2	20	20	115
March	620	53	23.4	-	0.79	0.7	0.0	0.2	22	25	96
April	960	58	13.1	-	1.77	-	-	-	-	-	-
May	3600	66	14.7	-	-	-	-	-	-	-	-
June	8300	78	8.4	-	1.65	-	-	-	-	-	-

*Flow measurements made at river mile 79.1

STATION NO. 22, RIVER MILE 46.4*

Month	Total Plankton no/ml	Temp. °F	Flow cfs x 10^{-3}	Velocity ft/sec	BOD (mg/l)	NO_3 (mg/l)	Org.N (mg/l)	PO_4 (mg/l)	SiO_2 (mg/l)	Turbidity (mg/l)	TDS (mg/l)
1960											
April	1700	60	17.2	1.85	1.20	1.0	0.2	0.1	15	2	-
May	790	65	16.9	1.82	1.86	0.7	0.2	0.3	19	60	-
June	1500	70	10.1	1.35	-	0.3	0.0	0.3	20	12	-
July	1800	72	10.4	1.38	1.85	1.1	0.2	0.4	19	2	-
August	2000	73	9.9	1.34	1.23	0.5	0.3	0.1	20	98	-
September	3800	70	9.2	1.27	2.06	0.7	0.2	0.4	22	12	130
October	2400	61	7.5	0.96	2.79	0.4	0.3	0.5	23	5	116
November	2300	54	12.3	1.48	2.11	1.4	0.0	0.3	19	40	107
December	680	46	13.8	1.59	2.35	0.8	0.0	0.2	20	30	98
1961											
January	710	45	13.2	1.55	2.31	0.6	0.2	0.3	20	25	110
February	360	50	33.6	3.15	1.27	0.5	0.2	0.2	20	57	94
March	520	52	23.8	2.56	1.37	0.6	0.2	0.2	21	24	93
April	880	58	19.7	2.01	1.93	-	-	-	-	-	-
May	4600	68	14.8	1.60	2.04	-	-	-	-	-	-
June	8900	78	9.2	1.17	1.88	-	-	-	-	-	-

* Flow measurements made at river mile 59.8

TABLE T-3 (Continued)

SACRAMENTO RIVER WATER POLLUTION SURVEY

RESULTS OF PLANKTON SURVEY

SELECTED PHYSICAL AND CHEMICAL DATA

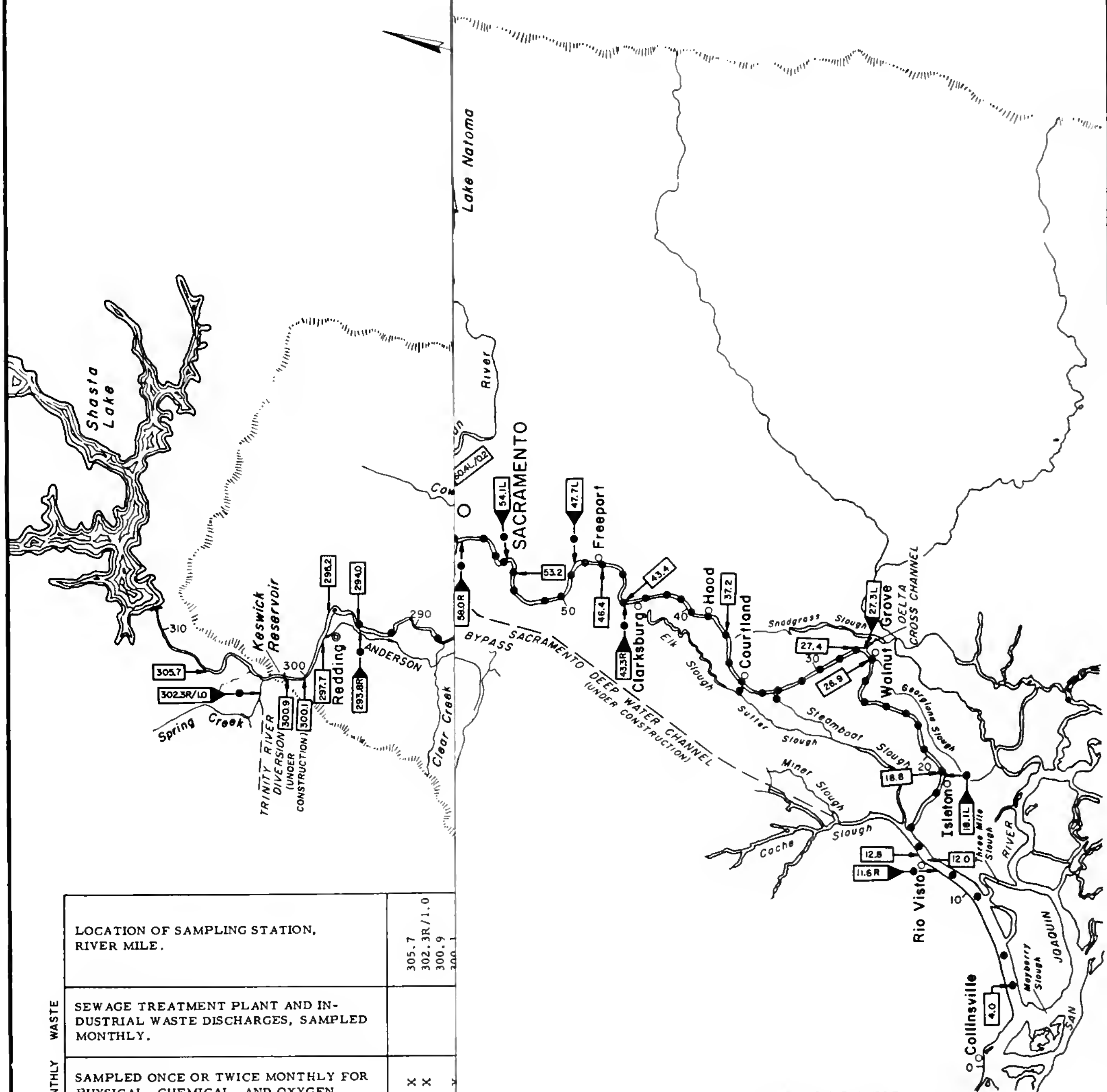
1960-1961

STATION NO. 26, RIVER MILE 18.8

Month	Total Plankton no/ml	Temp. °F	Flow cfs x 10^{-3}	Velocity ft/sec	BOD	NO_3	Org.N	PO_4	SiO_2	Turbidity	TDS
					mg/1						
1960											
April	1200	61	-	-	1.39	0.9	0.1	0.2	17	1	-
May	980	66	-	-	1.18	0.5	0.2	0.2	18	5.9	-
June	5100	69	-	-	-	0.4	0.2	0.2	19	15	-
July	5400	73	-	-	1.32	0.8	0.2	0.2	18	3	-
August	8100	73	-	-	1.40	0.6	0.2	0.3	20	10	-
September	4800	69	-	-	0.35	0.3	0.1	0.3	21	9	126
October	1500	61	-	-	1.00	0.5	0.2	0.4	22	15	120
November	2300	54	-	-	1.26	8.9	0.1	0.3	21	15	111
December	2200	49	-	-	1.76	1.0	0.1	0.3	20	37	126
1961											
January	1000	45	-	-	1.80	0.6	0.2	0.2	20	20	112
February	290	50	-	-	1.35	0.6	0.1	0.3	21	72	91
March	740	53	-	-	2.09	0.6	0.1	0.2	21	26	90
April	1500	60	-	-	0.90	-	-	-	-	-	-
May	3300	68	-	-	0.98	-	-	-	-	-	-
June	15,000	77	-	-	1.69	-	-	-	-	-	-

STATION NO. 28, RIVER MILE 4.0

Month	Total Plankton no/ml	Temp. °F	Flow cfs x 10^{-3}	Velocity ft/sec	BOD	NO_3	Org.N	PO_4	SiO_2	Turbidity	TDS
					mg/1						
1960											
April	1000	60	-	-	0.84	0.9	0.0	0.2	16	4	-
May	1300	64	-	-	1.33	0.6	0.2	0.2	21	121	-
June	3700	70	-	-	-	0.5	0.1	0.2	14	35	-
July	2900	71	-	-	1.03	0.2	0.2	0.1	10	15	-
August	2800	70	-	-	0.82	0.6	0.2	0.1	12	31	-
September	3600	66	-	-	1.04	0.4	0.2	0.3	18	44	478
October	2200	61	-	-	0.82	0.0	0.2	0.3	18	52	1268
November	2700	56	-	-	0.74	1.1	0.0	0.3	20	58	574
December	2000	48	-	-	1.12	1.5	0.1	0.2	19	48	150
1961											
January	1400	45	-	-	1.41	1.0	0.2	0.2	20	33	162
February	350	52	-	-	1.12	0.8	0.1	0.2	19	101	115
March	240	53	-	-	1.23	0.9	0.3	0.2	20	45	117
April	910	60	-	-	1.25	-	-	-	-	-	-
May	4900	63	-	-	1.48	-	-	-	-	-	-
June	12,000	69	-	-	1.87	-	-	-	-	-	-



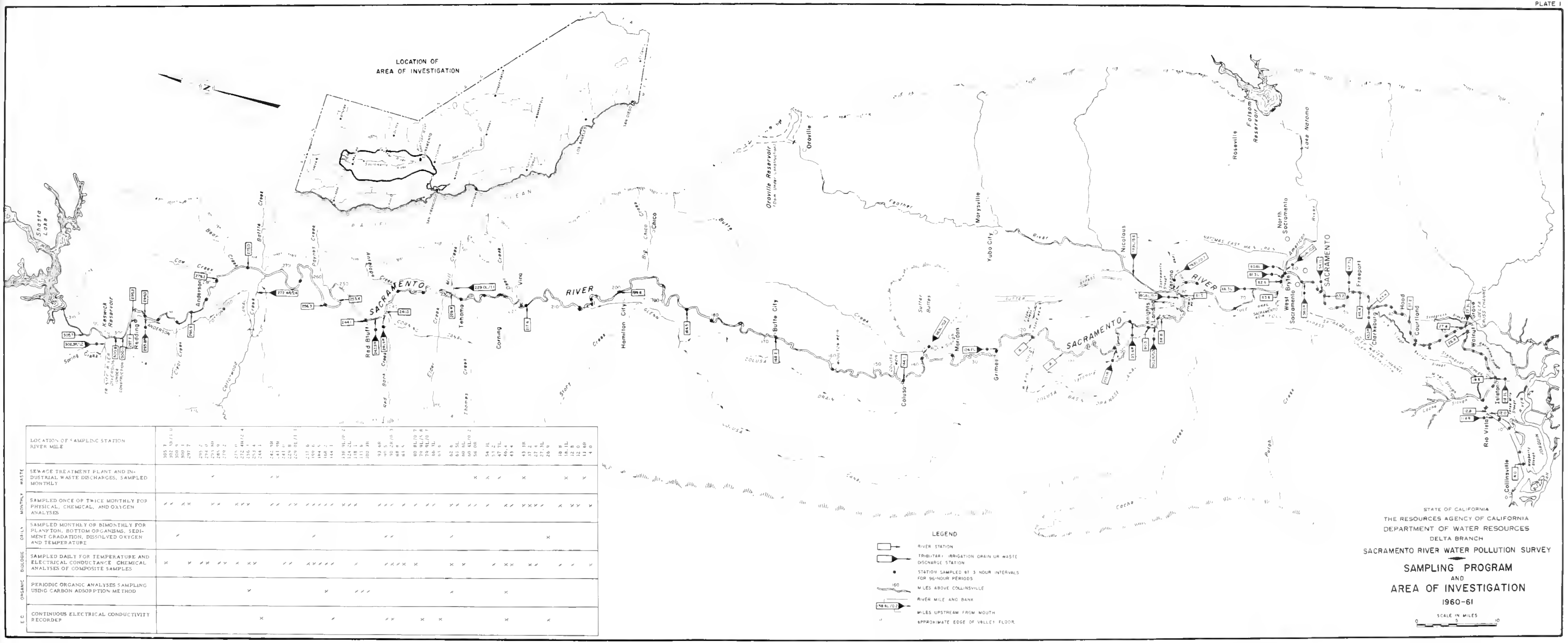
		305.7	302.3R/1.0	300.9	300.1
	LOCATION OF SAMPLING STATION, RIVER MILE.				
WASTE	SEWAGE TREATMENT PLANT AND INDUSTRIAL WASTE DISCHARGES, SAMPLED MONTHLY.				
MONTHLY	SAMPLED ONCE OR TWICE MONTHLY FOR PHYSICAL, CHEMICAL, AND OXYGEN ANALYSES.	X	X	X	
DAILY	SAMPLED MONTHLY OR BIMONTHLY FOR PLANKTON, BOTTOM ORGANISMS, SEDIMENT GRADATION, DISSOLVED OXYGEN AND TEMPERATURE.			X	
BIOLOGIC	SAMPLED DAILY FOR TEMPERATURE AND ELECTRICAL CONDUCTANCE. CHEMICAL ANALYSES OF COMPOSITE SAMPLES.	X			
ORGANIC	PERIODIC ORGANIC ANALYSES SAMPLING USING CARBON ADSORPTION METHOD.				
E.C.	CONTINUOUS ELECTRICAL CONDUCTIVITY RECORDER.				

STATE OF CALIFORNIA
THE RESOURCES AGENCY OF CALIFORNIA
DEPARTMENT OF WATER RESOURCES
DELTA BRANCH

SACRAMENTO RIVER WATER POLLUTION SURVEY

SAMPLING PROGRAM
AND
AREA OF INVESTIGATION
1960-61

SCALE IN MILES
0 5 10



	LOCATION OF SAMPLING STATION RIVER MILE
	305.7, 302.5R/1.0, 300.9, 300.1, 297.7, 295.2, 294.0, 291.8R, 285.9, 279.2, 275.0, 272.4R/2.4, 256.1, 253.4, 244.1, 242.9R, 241.9R, 241.0, 229.8, 229.0L/1.1, 217.6, 199.6, 184.5, 168.2, 144.1, 138.9L/0.2, 124.2L, 118.1, 111.6, 100.3R, 93.6R, 90.5, 90.2R/0.3, 88.8, 81.5, 80.8L/0.7, 79.9L/4.8, 79.9L/0.7, 66.1L, 61.0, 62.6, 61.5L, 60.6L, 60.4L/0.2, 58.0R, 54.1L, 51.2, 47.7L, 46.4, 43.4, 43.3R, 37.2, 27.4, 27.3L, 26.9, 18.8, 18.1L, 12.8, 12.0, 11.6R, 4.0
WASTE	SEWAGE TREATMENT PLANT AND INDUSTRIAL WASTE DISCHARGES, SAMPLED MONTHLY
MONTHLY	SAMPLED ONCE OR TWICE MONTHLY FOR PHYSICAL, CHEMICAL, AND OXYGEN ANALYSES
BIOLOGIC	SAMPLED MONTHLY OR BIMONTHLY FOR PLANKTON, BOTTOM ORGANISMS, SEDIMENT GRADATION, DISSOLVED OXYGEN AND TEMPERATURE
DAILY	SAMPLED DAILY FOR TEMPERATURE AND ELECTRICAL CONDUCTANCE. CHEMICAL ANALYSES OF COMPOSITE SAMPLES
ORGANIC	PERIODIC ORGANIC ANALYSES SAMPLING USING CARBON ADSORPTION METHOD
E C	CONTINUOUS ELECTRICAL CONDUCTIVITY RECORDER

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DELTA BRANCH

SACRAMENTO RIVER WATER POLLUTION SURVEY

SAMPLING PROGRAM AND AREA OF INVESTIGATION
1960-61